

ABSTRACTS - 2005
JOINT MEETING OF ICHTHYOLOGISTS & HERPETOLOGISTS
COMPILED BY M.A. DONNELLY

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Speciation observed in mid-stride: A multi-gene analysis of the California Tiger Salamander

The California tiger salamander (CTS: *Ambystoma californiense*) is a phylogenetically distinct, endangered member of the tiger salamander complex. A California endemic, its range spans from Santa Barbara County in the south to Sonoma County at its most northerly range limit. These two counties are also home to two geographically disjunct populations that are in severe decline due to urban sprawl and agriculture, resulting in emergency listing under the US ESA in 2000 (Santa Barbara) and 2003 (Sonoma). Previous work from our laboratory based on mitochondrial DNA variation, found six well supported population units within the CTS, with Santa Barbara and Sonoma populations each resolved as monophyletic and deeply differentiated. Because single gene trees may not represent population or species histories, we sequenced 10 unlinked nuclear loci with a size range of 350-1200 base pairs for up to 32 exemplar individuals from across the range. Based on neighbor-joining trees for each locus, we found consistent support for geographically-structured variation at two levels. Deep in the history of CTS, we found two distinct, reciprocally monophyletic clades from the western and eastern flanks of the Great Central valley. Within the eastern clade, the Santa Barbara population was clearly observed as a monophyletic group in a majority of the gene trees, although a few showed paraphyly with respect to one or two gene copies. When viewed as an Adams consensus tree of all loci, individuals from the Santa Barbara isolate were consistently nested within the eastern lineage. Sonoma, though not as strongly supported, was maintained in the western group with relative consistency. Our multigene analysis suggests that both the Santa Barbara and Sonoma populations are distinct lineages in the process of speciating. The Santa Barbara population is further along in the process of achieving complete lineage sorting, and is best considered as a new lineage-based species.

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A molecular dissection of the mating system in the bluntnose minnow,
Pimephales notatus

Pimephales notatus is a common cyprinid that is able to flourish in polluted waters and is found ubiquitously in many freshwater habitats in Eastern North America; yet the breeding behavior and genetic mating system of this species have not been documented in a natural stream setting. Male bluntnose minnows excavate and guard nest sites under slab rocks and contribute paternal care until the eggs hatch. From the large quantity of eggs observed in these nests, it

appears that multiple females contribute to each nest. Here we perform a molecular dissection of the bluntnose minnow mating system using three highly polymorphic microsatellite markers to quantify the total number of females contributing to a nest and to reveal any alternative mating tactics (ie. cuckoldry, nest takeover events, and nest-guard swapping) that could be employed by males to enhance their reproductive success. Approximately fifty embryos from each nest were genotyped at three different microsatellite loci and compared to the genotype of the guarding male captured with each nest. Preliminary results from several nests indicate a significant portion of the embryos are not sired by the guarding male. These results are compared to a recent molecular parentage study on a closely related species *P. promelas*.

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Defending the Alamo: Compensatory biotic and abiotic forces regulate species distributions in a salamander community

The Peaks of Otter Salamander (*Plethodon hubrichti*) has an extremely limited range, and is completely surrounded by the cosmopolitan red-backed salamander (*P. cinereus*). Based on this distributional pattern, and research on other geographically restricted *Plethodon*, it is widely believed that the range of *P. hubrichti* is restricted as a result of interspecific competition with *P. cinereus*. However, previous behavioral research demonstrated that aggression exists between the species, but *P. hubrichti* is the more aggressive of the two; an outcome that runs counter to expectations. We examined trophic morphology, food resource use, and climatic data from multiple allopatric and sympatric populations of both species to obtain a more comprehensive understanding of their ecological interactions. A total of 20 populations were examined. In contrast to predictions from a competitive model, there was no partitioning of food use between species, and sympatric populations were significantly more morphologically similar than expected from chance. Such sympatric morphological convergence suggests local adaptation, rather than interspecific competition. In addition, we identified a significant association of morphology and climatic variation across the entire region. Finally, using bioclimatic modeling, we found that the predicted ecologically-viable range of *P. hubrichti* was roughly concordant with its current distribution. In contrast, the predicted ecologically-viable range of *P. cinereus* engulfed nearly the entire distribution of *P. hubrichti*; a location not currently occupied by *P. cinereus*. Synthesis of current data and previous work strongly suggests that abiotic forces and local adaptation restrict *P. hubrichti* to its current distribution, while biotic interactions (aggressive interference of *P. hubrichti*) prevents *P. cinereus* from encroaching upon its range. If this system is at equilibrium, it represents a distinctive example of compensatory biotic and abiotic forces maintaining species distributions in an ecological community.

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Habitat and Prey Selection in two Species of *Imantodes*

Imantodes cenchoa and *Imantodes inornatus* are two sympatric species of vine snake found at La Selva, Costa Rica. Previous natural history observations suggest that the two species differ in their habitat and prey use. Field observations confirm that *I. cenchoa* selects forest habitats and *I. inornatus* selects swamp habitats. In an experiment in which tongue flicks directed at a prey-scented cotton swab were used to assess interest by snakes in a particular prey item, *I. cenchoa* responded positively to anoles but not frogs and frog eggs when compared to an inert control (water), and *I. inornatus* responded positively to scents from frog eggs but not anoles and frogs when compared to the same control. Finally, we document that the preferred prey items are more abundant in the habitats selected by each species.

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Status of conservation and population declines of amphibians of Bolivia

During the last years, the knowledge of the distribution and systematics of Bolivian amphibians has increased noticeably, but studies on ecology and conservation status remain scarce. Among the 230 species reported for the country, the list of threatened species varies from 3 to 21, depending on the authors. These species are threatened due to habitat loss (e. g. *Hyla charazani*), pollution, and trade for local consumption (e. g. *Telmatobius culeus*). Although declines of amphibian populations have been documented in neighbor countries due to the chytrid fungus *Batrachochytrium dendrobatidis*, in Bolivia its presence has not been reported yet. Nevertheless, there have been unpublished records of certain populations of *Telmatobius* and *Phrynopus* which have suffered drastic decreases in cloud forests of Cochabamba, and dead specimens have been found. These decreases might be due to the presence of chytrids but this topic needs further research. Here we present the basis of a project that will study the problem by: 1) monitoring Bolivian amphibian populations in sites of past surveys to reveal possible declines; 2) detecting the presence or absence of chytrids in certain populations; and 3) establishing, if chytrids are found, the date of introduction of this fungus in the country by tissue sampling in specimens of scientific collections.

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The evolutionary trajectory of a recently established Alaskan threespine stickleback population

Postglacial adaptive radiation of the threespine stickleback fish, *Gasterosteus aculeatus*, provides one of our most enlightening cases of evolutionary diversification. Little is known, however, on the actual rate at which resident freshwater stickleback populations evolve, or the evolutionary trajectories they take. A newly established population in Loberg Lake, located in the Cook Inlet region of Alaska, is providing a rare glimpse into the evolution of freshwater stickleback populations. The population was established by anadromous (ocean-run) stickleback within a decade of when sampling began. Annual samples collected since 1990 indicate that armor traits for this population are evolving rapidly in the direction of neighboring resident lake populations. I describe the pattern of divergence in body shape of the Loberg Lake population over time using geometric morphometric methods. The evolutionary time series for Loberg Lake is projected onto a morphospace created from variation of neighboring lake and stream populations sampled between 1990-1992 and 2003-2004. Early in the time series, the Loberg Lake population is similar to its anadromous ancestor in body shape, but other phenotypic traits indicate that the specimens sampled developed in the lake. The population then quickly becomes similar to extreme lake benthic populations from the region, with the rest of the time series changing much more gradually and generally approaching the phenotype of the extinct population originally inhabiting the lake. The influence of ancestral phenotypic covariation on the evolutionary trajectory of the Loberg Lake population is also assessed. **STOYE ECOLOGY & ETHOLOGY**

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Prey capture kinematics of the chain catshark *Scyliorhinus retifer*

Past studies of feeding kinematics in the elasmobranchs (sharks, skates and rays) have focused on easily accessible species inhabiting the epipelagic portion of the ocean. Thus, our knowledge of feeding behavior in deeper dwelling elasmobranch fishes is strictly limited. The chain catshark (*Scyliorhinus retifer*) is a member of one of the most well researched groups of elasmobranchs (order: Carcharhiniformes), but this particular species inhabits a deep-sea environment and its feeding strategies are therefore unknown. In an attempt to better understand the feeding biology of *S. retifer* we utilized high-speed videography to document the kinematic events during prey capture. Sharks were filmed feeding on pieces of Atlantic silversides (*Menidia menidia*) scaled to the mouth diameter (large prey) and one-half the mouth diameter (small prey). Frame-by-frame analysis of kinematic variables indicated that the chain catshark utilizes mild suction to capture benthic prey items. Univariate ANOVAs found that prey size did not significantly affect the majority of kinematic variables. Though kinematic displacement measurements differed significantly between individuals, the timing of most movements did not. Only two timing variables,

time to minimum lower jaw angle and time to maximum hyoid displacement, were found to vary significantly between large and small prey items. However, a MANOVA of principal components found no significant differences when simultaneously analyzing all derived kinematic variables for the effect of prey size. These results suggest that *S. retifer* exhibits stereotypical feeding behavior when capturing benthic prey. The feeding behavior of the chain catshark shows a strong connection to the basic pattern of kinematic events described in feeding studies of other carcharhiniform sharks. Nonetheless, stark differences in RSI values and the timing of upper jaw protrusion between this species and *Cephaloscyllium ventriosum* indicate that multiple prey capture strategies exist within the family Scyliorhinidae. **AES GRUBER**

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Accounting for incomplete detection when estimating site occupancy of *Pteronotropis welaka* in southwest Georgia

Accurate assessment of habitat requirements, range and overall conservation status requires sampling methods that have a high probability of detecting the target species. Seining is a commonly used method to sample cyprinids in coastal plain streams of the southeastern United States, but detection probabilities using this gear type are usually unknown. In conjunction with a status assessment for *Pteronotropis welaka*, we surveyed 38 sites in the Flint basin of southwest Georgia using seines. The probability of detecting *P. welaka* during a single seine haul was substantially lower (0.06) than for *Notemigonus crysoluecas* (0.19), *Notropis harperi* (0.23) and *Pteronotropis grandipinnis* (0.33). Because of the large number of seine hauls we carried out at most sites (12-30 hauls), the proportion of sites where species were actually detected differed little from estimates of site occupancy that accounted for incomplete detection. For example, we detected *P. welaka* at 8% of our sites, but Program presence estimated that this species occurred at 10% of our sites. However, the standard error of the estimated proportion of sites occupied was much higher for *P. welaka* (0.42) than for the other species (0.08 for all three), indicating great uncertainty in the true number of sites occupied in southwest Georgia. To get a better estimate of site occupancy, we plan to model detection probabilities as a function of habitat characteristics, examine data from other recent surveys in the range of *P. welaka*, and conduct additional sampling.

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Reproductive biology of the Massasauga (*Sistrurus catenatus*) from south-central Illinois

This study was conducted at Carlyle Lake, Clinton County, Illinois. Preserved specimens examined for this study are in the Illinois Natural History Survey collection. Based on preserved snakes females initiate vitellogenesis in the summer/fall. Vitellogenic follicles reach 20 mm in length by late September. Follicles overwinter at this size and resume growth in the spring. Ovulation occurs the later in the spring. Spermatogenesis begins June and peaks in August and September. The diameter of the seminiferous tubules is less than 200 μ m in May and reaches a diameter of 300 μ m in late July to early September. The sexual segment of the kidney parallels the diameter of the testis. Sexual segment tubules are lowest in the early part of the active season and peak in diameter and secretory activity in August through September. Mating and male-male combat occur primarily in the summer when the sexual segment of the kidney is hypertrophied. As in other species of snakes, the sexual segment of the kidney never regresses completely, indicating that testosterone levels are elevated throughout the year. Elevated plasma testosterone may be necessary for long term sperm storage in the vas deferens. This elevated testosterone may also account for the presence of reproductive behaviors sometimes observed in snakes.

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Thermal biology of *Python natalensis*: Does temperature limit distribution?

Python natalensis occurs in Africa, from the equator southwards to the northern and eastern parts of South Africa. The southern edge of the distribution correlates well with isotherms (e.g., Daily Mean, Mean Daily Max, ET), suggesting that low temperatures may be the proximal limiter to distribution. This hypothesis is especially plausible because *P. natalensis* is large and heavy-bodied, reaching a body mass in excess of 55 kg. Low rates of body temperature (T_b) increase could thus severely limit the amount of time spent at selected T_b, especially in cooler areas. I measured rates of heating and cooling of 16 free-ranging pythons in the Limpopo Province of northern South Africa, near to the southern range edge for the species. I predicted that if temperature was the proximal range limiter, pythons would be limited to achieving selected T_b for a relatively small portion of each day. Although small pythons are able to heat more quickly than large ones, rates of heating for large pythons are still sufficiently fast to ensure that only a small portion of the day is required for basking. Thus, temperature does not appear to limit distribution by limiting time spent at selected T_b. This is further supported by data recorded from snakes incubating eggs: Selected T_b for incubating females is 37 °C, significantly higher than the 30 °C selected by nonbrooding females or males. Since brooding females are usually large, select higher T_bs, do not display shivering thermogenesis, and

only bask for relatively short periods of time, this demonstrates that *P. natalensis* has the potential for rapidly raising Tb well above the usual selected Tb. However, the presence of Aardvark (antbear) burrows appears to be critically important to the occurrence of *P. natalensis* as they provide stable thermal environments for the pythons.

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Phylogeny of the Oriental-Australian rear-fanged water snakes (Colubridae: Homalopsinae) based on DNA sequences

The Homalopsinae (Oriental-Australian rear-fanged water snakes) is a colubrid subfamily containing 10 genera and 34 species known for its ecological and morphological diversity. Here we build on our past work to present the results of an expanded molecular phylogenetic study of the homalopsines. First, we test the monophyly of the homalopsines using parametric bootstrapping and Bayesian analyses. We sequenced 21 homalopsine species for a portion of the *c-mos* gene and added 186 outgroup species available on GenBank to create a matrix of 207 taxa. Our analysis included representatives of nearly every major snake lineage and found significant support for the hypothesis that homalopsines form a monophyletic assemblage. Second, we present a molecular phylogenetic analysis of the homalopsines based on sequences from portions of three mitochondrial genes (12S, 16S, and Cyt *b*) and one nuclear gene (*c-mos*) from 21 ingroup and seven outgroup species. Maximum likelihood, Bayesian, and parsimony analyses were largely concordant and revealed strong support for many nodes throughout the tree. The marine crustacean eaters, *Fordonia leucobalia* and *Gerarda prevostiana*, formed a well-supported clade with *Cantoria violacea*, another crustacean eater, being its closest sister species. *Enhydria*, the most species-rich genus in the subfamily, was polyphyletic in our analyses, although five morphologically and ecologically similar species formed a well-supported clade. We discuss the evolutionary and ecological implications of these findings.

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Effects of varanid top predators on skink mesopredators and their prey

Top predators tend to disappear from anthropogenically altered habitats. Understanding the effects of these disappearances is critical for conserving remaining trophic levels, because top-level predators influence assemblage structure at lower trophic levels via both direct and indirect effects. There is,

however, no consensus on the size, direction, or nature of these effects, especially in terrestrial ecosystems. We studied the influence of top predator (varanid lizard) removal on skink mesopredators and lower trophic levels in the Australian tropics using a large-scale manipulative experiment. We used an array of 14 x 14 m (200 m²) enclosures, plus unenclosed plots of the same size, to expose plots to three experimental treatments: 1) control plots with natural varanid and skink densities, 2) plots with varanids excluded, but skinks allowed access, 3) unenclosed plots to control for enclosure effects. There are four replicates of each treatment. Excluding varanids had small effects on the composition of the skink assemblage, but had little effect on skink abundance. Despite this, varanid exclusion strongly affected the abundance and composition of the assemblages of spiders and litter invertebrates that serve as prey for skinks. Many of these changes appeared to be trait-mediated indirect effects caused by changes in the behavior of skinks in response to changes in their exposure to the risk of predation from varanids. It thus appears that in our study system, the strongest effects of top-level varanid predators on the food web may arise through trait-mediated indirect effects on mesopredators, rather than more direct effects on their abundance.

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Reproductive biology of *Potamotrygon scobina* Garman, 1913
(Chondrichthyes: Potamotrygonidae) in the Marajó Bay region, Pará,
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Potamotrygonids present a reproductive mode described as matrotrophic viviparity with *trophonemata*. This study presents the results on the reproductive aspects of the freshwater stingray *Potamotrygon scobina* in the Marajó Bay region. The specimens (n = 244) were sampled in the Colares Island region in the years 2000 through 2002. Males (n = 120) and females (n = 124) had their main reproductive characteristics analyzed in the field and in laboratory. All reproductive organs and embryos were fixed in formaldehyde solution (10%) and preserved in ethanol (70%). The HSI and GSI were also calculated for juveniles, sub-adults and adult specimens of both sexes. HSI values varied from 2.75 - 4.86 for males and 3.48 - 7.34 for females. GSI values varied from 0.17 - 0.65 for males and 0.16 - 0.45 for females. The Pearson Correlation Coefficient (r) of the disc width and clasper length was of 0.80. Abundant semen and spermatophores were present in 20.83% of the males sampled and were only observed at a minimal disc width of 358 mm. Embryos (n = 162) were present in 41.33% (n = 31) of the adult females sampled and were only observed at a minimal disc width of 387 mm. Adult females presented an average ovarian and uterine fecundity of around 5. The Pearson Correlation Coefficient (r) of the disc

width and number of embryos was of 0.66. Slight salinity changes seem to play an important role as a trigger for reproduction in the *P. scobina* population of this region. The results obtained indicate that the reproductive cycle of *P. scobina* is closely related to the hydrologic cycle of the Amazon Estuary region. (Supported by CNPq, CAPES and WWF - Brazil grants).

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Osteological development of *Diapterus peruvianus* (Percoidei: Gerreidae)

Osteological studies of *Diapterus peruvianus* are scarce and based on adult specimens. Because of this, our objective was to describe its osteological development using a series of 12 cleared and stained specimens wild caught (2.7 - 20.8 mm). In the smallest specimen analyzed (preflexion larvae) at 2.7 mm NL (notochordal length), the jaws, suspensorium, and opercular series were ossified and the neurocranium remained cartilaginous. A premaxillary ascending process could be observed at 3.8 mm NL, and the caudal and dorsal fins supports were present. At 4.8 mm SL (standard length) in the postflexion larvae, the frontals were ossified and had 24 vertebrates, the number of caudal fin rays, and the first rays and spines of the dorsal and anal fins were completed. At 6.1 mm SL, the preopercle had three spines, the 3th and 4th hypurals were fused, and the dorsal and anal fins were fully formed. In juvenile specimens at 9.2 mm SL, a supraoccipital crest was visible, the 1st and 2nd hypurals were fused and the pectoral and pelvic fins were completely formed. By 20.8 mm SL, the caudal supports were fully ossified.

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Masking interference and the evolution of the acoustic communication system of the poison frog *Epipedobates femoralis*

The efficacy of communication relies on detection of species-specific signals against the background noise. Features affecting signal detection are thus expected to evolve under selective pressures represented by masking noise. Spectral partitioning between the auditory signals of co-occurring species has been interpreted as the outcome of the selective effects of masking interference. However, masking interference depends not only on signal's frequency but on receiver's range of frequency sensitivity; moreover, selection on signal frequency can be confounded by selection on body size, because these traits are often correlated. We used the widely distributed Amazonian frog species, *Epipedobates femoralis*, to test whether geographic variation in communication traits agrees with predictions about masking interference. We considered two scenarios: masking interference may increase with the number of acoustically coactive species or with the occurrence of a single species, *E. trivittatus*, calling within an overlapping frequency range. We analyzed the signal's spectral features of all coactive species at eight sites throughout the Amazon basin. Since territorial males of *E. femoralis* strongly react to the presence of vocally active intruders, we used playback experiments under natural conditions to derive frequency-recognition curves. Most geographic variation in studied traits was correlated with either call frequency or with response frequency range. The calls of *E. trivittatus* partially overlapped with the calls of *E. femoralis*. The occurrence of *E. trivittatus* significantly predicted narrower and asymmetric frequency-recognition curves in *E. femoralis*, without concomitant differences in the call or in body size. The number of species did not significantly predict variation in any of the studied traits. Our results strongly support that the receiver but not the sender component of the communication system changed due to masking interference by a single species.

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Plastic gonads: Do they exist?

There is considerable plasticity in size at metamorphosis in many species of amphibians. For example, tadpoles developing in low quality (i.e. low food) habitats grow slowly and are smaller at metamorphosis than conspecifics from high quality environments. Similarly, larval amphibians developing in temporary ponds will often quickly metamorphose in response to decreasing water levels resulting in small size at metamorphosis. It is believed that amphibians that metamorphose at larger sizes survive better and reproduce at

younger ages than animals that metamorphose at smaller sizes. One hypothesis for this relationship is that small metamorphs may simply not be in adequate condition (weight to length ratio) to reproduce in the first year. Alternatively, individuals in less hospitable environments may allocate more energy toward developing structures necessary for metamorphosis than toward growth, or gonad development. The ability to differentially allocate energy between somatic and reproductive development could be an important mechanism by which development of structures required for metamorphosis (i.e. limbs, or carnivore gut) can be maximized when environmental conditions are unfavorable at the expense of reproductive organs which could be developed in the next life history stage. Few studies have explicitly tested whether growth or developmental rates of gonads in amphibians are plastic. We designed two experiments to test the hypotheses that 1) Animals fed a restricted diet would have less developed gonads and lower condition at metamorphosis than those fed large quantities, and 2) Developmental rate of gonads is slower and not dependent on somatic development in food restricted animals. We discuss the conservation implications of this work.

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A survey of squamate biodiversity at Reserva Amazonica, Peru.

Reserva Amazonica, Peru is an ecotourist lodge constructed in 1974. In 1979, 10,000 ha of lowland rainforest neighboring the lodge were designated as a private reserve for biological investigation and tourism. Herpetofauna surveys of Reserva Amazonica, since BIOTROP (Neotropical Biological Diversity Program) in 1989 have chiefly focused on the 64 frog species inhabiting the area. In view of this, less data has been collected regarding the 81 reptile species on the site. Between 26 December 2004 and 16 January 2005, eleven researchers performing a survey of amphibians and reptiles logged 240 person days. Transects were walked nightly along the existing trail system by groups of two or more people. Additionally, funnel traps were placed along root buttresses and fallen trees proving successful in capturing fossorial snakes. A total of 39 reptile species were recorded from 109 observations. The previous survey in 2002-2003 compiled 50 observations of 21 reptile species over a total 114 person days logged. Of the 39 species recorded one *Typhlops reticulatus* had never been recorded at the site and at least one other *Platemys platycephala* had not been recorded since the original BIOTROP surveys.

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Genetic investigation into the origin of the Waccamaw Silverside *Menidia extensa*

Lake Waccamaw is one of the Carolina Bay Lakes which despite its relatively recent formation (25,000 -100,000 years ago) is home to three endemic freshwater fish species. Even more surprisingly, one of these endemics, the waccamaw silverside (*Menidia extensa*) is a member of a genus that is almost exclusively marine. Using both mitochondrial and nuclear loci, we examined the origins and population genetics of *Menidia extensa* as well as its relationships to its putative sister species, *Menidia beryllina*, and other members of the genus *Menidia*.

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Population genetic variation and gene flow among communal hibernacula of timber rattlesnakes (*Crotalus horridus*) in western St. Louis County, Missouri

We used nine polymorphic microsatellite loci to examine genetic relatedness within a local timber rattlesnake population. First we tested the hypothesis that den site fidelity creates system of mating inbreeding within dens by: 1) computing multilocus F_{IS} (f) values for groups of individuals of known den residence, and 2) estimating relatedness values within these same groupings. Next we tested the affect of female fidelity to nursery areas near dens on genetic relatedness among dens by: 1) comparing relatedness estimates among groups of proximal dens, and 2) comparing the relatedness values of males and females within these groups. The results of these analyses were compared to similar studies on this and other rattlesnake species and directions for future research are presented.

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Soniferous fishes in the Hudson River: Focusing on tidal freshwater Tivoli Bays

The purpose of this study was to catalogue types of underwater sounds recorded in the Tivoli Bays National Estuarine Research Reserve (NERR) located on the Hudson River. Although soniferous fishes have been studied in many different parts of the world, very few studies have been conducted in North American

freshwater systems. We recorded underwater sounds with an autonomous underwater listening system consisting of a hydrophone, digital sound recorder, and weatherproof housing. In the first year of the study 46 hours of unmonitored recordings were collected in mid-summer from two locations within the Tivoli Bays NERR. We identified 17 different sounds of interest. Although the specific identifications of these sounds were unknown, we categorized five sounds as most likely produced by fishes, seven as from an unknown biological source and two from a non-biological (man-made) source. Four sounds could not be identified to any of the categories and were classified as unknown. In the second year we attempted to identify the source of the observed sounds by conducting manned recording sessions and controlled sound auditing of fishes. We recorded sounds produced by two species of catfish: brown bullhead, *Ameiurus nebulosus*, and channel catfish, *Ictalurus punctatus*. This study reveals that unknown underwater sounds are diverse in the Tivoli Bay NERR and strongly suggests that passive acoustics can be an important new tool for the study of the bay's ecology. Future research focused on the identification of these unknown underwater sounds promise to provide scientists with new insights into the ecology of the Tivoli Bay NERR. **STOYE ECOLOGY & ETHOLOGY**

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Snakes scentmark salient sites?

The selection of an ambush site is of paramount importance for sit-and-wait foragers. It has been suggested that predators revisit sites of prior success, but any means for recognizing sites with higher encounter probabilities would be advantageous. I have been studying the behavior of free ranging cottonmouths, *Agkistrodon piscivorus*, in wooded swamps of the southeastern USA. I use camcorders with near-infrared sensitivity to record the foraging movements of individuals over the course of an evening. Cottonmouths move more often than some better studied pit vipers; they occupied 1-5 sites (mean = 1.8) over 2-8 h intervals. Haphazard observations of prey encounters have provided insight into site selection. Though sample size is small, the cumulative impact of the observations is to clearly suggest that cottonmouths scentmark noteworthy locations. Within minutes of an encounter, cottonmouths rub their chin and sides of their head on relatively permanent, vertical structures like emergent wood. Such chemical signposting may not be limited to ambush sites, as one individual conspicuously marked at the "threshold" of its retreat. I discuss the implications of this behavior for foraging success. This behavior may provide insight into the chiseled facial angles of Agkistrodontini, and begs a histological/chemical analysis of the facial skin. It also suggests many possible behavioral tests with experimenter placed scentmarks.

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The grass is greener: Costs of diet switching may inhibit insect eating by herbivorous lizards

Herbivory is rare in reptiles and speculation on why strict herbivory has evolved spans more than four decades. When fed insects or meat, captive herbivorous reptiles grow faster, reach a larger size, and produce more offspring. If eating insects is advantageous for captive herbivorous reptiles, then why don't herbivores seasonally switch to eating insects in nature? We tested the hypothesis that diet switching is costly for herbivorous lizards. Changes in diet were expected to alter gut physiology (e.g., nutrient transport) or the gut milieu (e.g., pH) making conditions less favorable for fiber-fermenting bacteria, thus altering the bacterial community and evoking a concomitant decline in the host's digestive efficiency. To test these predictions, herbivorous desert iguanas (*Dipsosaurus dorsalis*) were fed ground alfalfa (herbivore) or cricket (carnivore) diets for 5 weeks, switched to the alternative diet for 5 weeks, then switched back to the original diet for 5 weeks. Another treatment group received an omnivorous diet (50:50 alfalfa:crickets) for all 15 weeks. Fecal samples were used to determine whether diet switches were associated with changes in (1) apparent digestive efficiency, (2) nitrogen assimilation, or (3) the hindgut bacterial community (via numerical analysis of fecal banding profiles using PCR-DGGE). We also compared gross morphology and physiology (pH and rates of nutrient transport) of lizard guts across diet treatments. Bacterial communities inferred from fecal samples were individual specific, but varied with diet type and length of time lizards were fed a particular diet. Diet switches were associated with changes in gut morphology, pH, amino acid transporter activity, and digestive efficiency. These morphological and physiological changes tracked changes in the endosymbiont community. Because diet switching alters gut structure and function, as well as disturbs the endosymbiont community, then seasonally switching between insect and plant diets may be disadvantageous for herbivorous lizards in nature. **SSAR SEIBERT MORPHOLOGY & PHYSIOLOGY**

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What is the half-life of a dead snake? Persistence of road-killed snake specimens as affected by scavengers, traffic density, and abiotic factors

Road counts of dead snakes are commonly used as estimates of overall road mortality levels on roads and relative abundances of species. However, counts are likely to be underestimates due to unobserved specimens that were removed by scavengers or simply destroyed by being run over repeatedly. We conducted a study in summer 2003 that was replicated in fall of the same year to determine

the persistence of snake carcasses on roads after being hit by a vehicle. Intact snake specimens that had been collected on roads were randomly assigned to one of three treatments: high traffic density, medium traffic density, and a closed road that served as a control. The rate of removal was highest at the lower traffic density, the primary scavengers being birds. Removal rate was lowest on the control road, the primary scavenger being ants, but birds arrived later in the experiment. The type of scavengers and the subsequent rate of removal were affected by abiotic parameters, particularly temperature and precipitation. Shorter and smaller snakes did not disappear more quickly as hypothesized. Whereas scavenging was reduced at the higher traffic density due to peak traffic flows coinciding with morning bird activity, smaller sizes were more often removed physically by vehicular traffic. A more thorough understanding of the variables influencing road kill persistence will allow a more accurate system in estimating true road mortality rates and relative abundances of snakes.

STORER - HERPETOLOGY

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Snakes on roads: Interspecific and intraspecific patterns of behavior as evidenced by a long-term database in the southeastern United States (1951-2005)

Researchers who use road cruising techniques are aware that some species of snakes are more characteristically observed on roads than others. However, the reasons that species are not observed at comparable frequencies need further investigation to determine why road crossing or avoidance varies among species. While many factors are involved in detection probabilities of species on roads, a first step in understanding the processes involves determining interspecific on-road frequencies and potential sources of detection biases. More than 16,000 individuals of 35 species of snakes were recorded from 1951-2005 on the Savannah River Site in South Carolina, permitting a comparison across species of capture frequencies as influenced by on-road and off-road techniques. Venomous or terrestrial species of snakes were significantly more likely to be found on roads than off roads when compared to non-venomous or aquatic species. A significant relationship was observed between the body size of species and their propensity to be captured on roads in that larger species are more likely to be detected. Males were more likely to be observed on the road than females for almost all species. The findings provide insights into how the ecology of a species relates to road-crossing tendencies and the efficacy of using road surveys for sampling snakes. Despite its many limitations, road cruising can be an effective technique for sampling snakes if these biases are understood and when used circumspectly with other methods.

SSAR SEIBERT ECOLOGY

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Issues of species identity and how these can bias population assessments

In order to address any biodiversity conservation issue and attempt the implementation of a conservation action plan, certain basic elements are necessary, such as the selection of the target species or ecosystem, some knowledge of its area of occurrence, geographic distribution, abundance or population density, and the problems affecting its survival or stability. However, in order to do this effectively, the conservation target has to be properly identified. If it is not, conservation action is bound to be flawed, ineffective or, in the best case scenario, hindered. Clear-cut definitions at the species level are nevertheless problematic. To this date, there is no consensus among taxonomists and systematists on a universally accepted species definition. There are over 22 species concepts in existence, and differences of opinion among experts as to what constitutes a species, so how can we ensure that we are talking about the same biological entities? The problem is compounded in certain taxa, such as amphibians, given the great number of morphologically cryptic species, and the potential for many new, unacknowledged species. Conservation attempts can thus be affected by biodiversity underestimates, and can result in inappropriate conservation action if the needs of cryptic species differ from those of their masking species. Herein we discuss how these issues of species identity can affect population assessments, and propose the use of certain tools to most accurately reflect the biological identities of selected amphibian taxa.

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Interactions between native and introduced guild members: responses of juvenile terrestrial salamanders to predatory invertebrates

When introduced species invade ecosystems, alterations in community structure can emerge from the competitive and predatory interactions that occur between introduced and native guild members. Because a number of recent studies have shown that large predatory invertebrates can both compete with, and prey on, small vertebrates, we examined the effects of introduced (*Lithobius forficatus*) and native (*Scolopocryptops sexspinosus*) centipedes on juveniles of the red-backed salamander (*Plethodon cinereus*). We addressed the following questions: 1) Do adult centipedes exclude juveniles of *P. cinereus* from cover objects in the field or in the lab? 2) Do juveniles of *P. cinereus* respond differently to the odors of, or to laboratory encounters with, either species of centipede? 3) Do adult centipedes of either species prey on juveniles of *P. cinereus*? In laboratory arenas, juvenile salamanders exhibited submissive behavior in response to the odors of both species of centipede, but the way in which they responded differed. Juveniles of *P. cinereus* spent significantly more time in escape behavior when presented with

native centipede odors and tended to remain immobile and flattened when exposed to odors of introduced centipedes. Despite significant size differences between centipedes and salamanders, no predation of juvenile salamanders by either species of centipede occurred in any pairings. Juvenile salamanders were more aggressive toward native centipedes and exhibited more chemosensory behavior toward native centipedes and their odors. Field and laboratory data suggest that juveniles of *P. cinereus* negatively associate with centipedes. In laboratory trials, the native centipede excluded juvenile salamanders from cover and we found fewer instances of co-occurrence of these two species in the field than expected. These studies are the first to examine the potential interactions between juveniles of a top predatory salamander and two intermediate predators, one introduced and one native, of eastern deciduous forest floor food webs.

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Behavioral time budgets of *Zebrasoma flavescens* in an artificial and natural ecosystem

Herbivorous fishes are considered a key element in the ecology of reef systems, as they are one of the most numerically abundant teleosts found on tropical coral reefs. Large schools of grazers have been observed to significantly reduce turf algae on areas of reefs that once supported dense patches. This study focuses on the behavioral time-budget of the yellow tang, *Zebrasoma flavescens* (Acanthuridae), with an emphasis on its feeding strategy. The importance of studying herbivory in an enclosed system is such that space and resources become limited, especially if nutrient and light levels are low. Fish must find a way in which to budget their time in order to achieve an optimal energy gain. I observed *Z. flavescens* in the Biosphere 2 Center (B2) Ocean Biome and on natural reefs in Hawaii. Fish in the B2 Ocean displayed four discrete behaviors (feeding, hovering, aggression, and fleeing), which were recorded and timed while snorkeling. Feeding accounted for 48% of their day, hovering 52%, aggression 0.55%, and fleeing from conspecifics 0.87%. On Hawaiian reefs, *Z. flavescens* were observed to spend 22% of their time feeding, and 62% swimming (not hovering), while aggression accounted for 0.13% and fleeing only 0.08%. Time allocated for feeding between the two sites was significantly different ($p < 0.001$). Results from this investigation suggest that variation in resource availability between the two sites affects the behavior and time budget of *Z. flavescens*. **STOYE GENERAL ICHTHYOLOGY**

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The morphology and uses of shark vertebrae

Known shark vertebrae may be divided into eight groups, a method that has to date been little used. One of these is called the lamnoid group, which will be

discussed here. Lamnoid vertebrae occur in two orders of sharks the Orectolobiformes and the Lamniformes. We here concern us with the 15 living species of Lamniform sharks. Externally the vertebral column can be divided into cervical, trunk, and caudal vertebrae. In general samples of vertebrae are taken just in advance of the dorsal fin. Posterior to this position vertebrae have little use in morphological studies. A pin can mark caudal vertebrae for x-rays or by simply cutting of the tail at the base. Cervical vertebrae show a slightly different morphology. Often the first is a hemi-vertebra attached to the endocranium. The configuration of the structures and in general number of vertebrae has value in separating the 15 Lamniform species. Vertebrae can be x-rayed or ground to their center to reveal their internal structure this may vary greatly depending in the position in the column. An understanding of the internal morphology is believed possible if taken from the correct part of the column to identify the 15 living species. The annular rings found in vertebrae are useful in age and growth studies. As with teeth, it is necessary to completely understand the vertebrae of living sharks before interpretations of the vertebrae in the fossil record will have true meaning.

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Elasmobranchs grow in length according to a two-phase growth model

Often, it is assumed that the von Bertalanffy growth model (VBGM) is appropriate to describe growth in length of elasmobranchs. However, a review of the literature suggests that a two-phase growth model could better describe growth in elasmobranchs. In this paper, we compare the two-phase growth model (TPGM) with the VBGM for 18 data sets of elasmobranch (16 species), by fitting the models to 36 age-length data pairs available (female, male and both sexes pooled). The Akaike Information Criteria (AIC) and the difference in AIC between both models revealed that in 23 cases (from 36) the probability that the TPGM was correct $\geq 50\%$. The VBGM tends to estimate larger L_{∞} values than the two-phase growth model, while the K parameter tends to be underestimated. We show growth rate in length tends to decrease near the age at first maturity in several species of elasmobranch. This growth pattern seems to be a characteristic of elasmobranchs. The importance of the TPGM lies in that it appropriately describes this aspect of the life history of the species. In this context, we conclude that the VBGM is not appropriate to describe the growth of elasmobranchs, and that the TPGM should not be overlooked, particularly in stock assessment models.

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Application of bomb radiocarbon chronologies to Shortfin Mako (*Isurus oxyrinchus*) age validation

Age estimation is an issue for the shortfin mako (*Isurus oxyrinchus*) because of ongoing disagreement on the periodic deposition of vertebral growth bands. A band pair is defined as a set of opaque and translucent bands in vertebral centra. Using four age determination techniques, Pratt and Casey (1983) concluded two band pairs formed annually; however, Cailliet et al. (1983) assumed one band pair per year. To evaluate the validity of both interpretations, a new technique was applied using radiocarbon measured in shark vertebrae. In the 1950-1960s, thermonuclear testing released large amounts of radiocarbon into the atmosphere, which reacted to form $^{14}\text{CO}_2$ and entered the ocean through gas exchange over the following years. This influx created a time-specific marker in the marine environment that can be used in age validation. In the first application to elasmobranchs, Campana et al. (2002) validated the vertebral ageing methodology for the porbeagle (*Lamna nasus*) and assayed four samples from one shortfin mako vertebra, suggesting annual deposition of one band pair for both species. In the present study, band-counting age estimates from 54 shortfin mako vertebrae collected in 1950-1984 ranged in age 1-31 years. Bands in early stages of life appeared broad and clear and became less defined with age. Ageing error between readers was consistent, with 76% of the estimates ranging within two years of each other. Twenty-one radiocarbon values from vertebrae of eight shortfin makos (collected in the Western North Atlantic in 1963-1984) ranged between -160.2‰ and 86.8‰. The resulting concordance with the porbeagle indicated shortfin mako has longevity of at least 31 years and supports annual deposition of a single pair of growth bands. This work was performed, in part, under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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Trophic position and environmental correlates of the abundances of three turtle species in north Florida lakes

Lakes in the southeastern United States support a high diversity and abundance of reptiles and amphibians, including many species of turtles. However, the role of turtles in lake food webs has never been studied, as most food web research is based on north-temperate systems with low turtle abundance. The objective of

this study was to determine if trophic position influences the habitat distribution and abundance of three turtle species across a lake productivity gradient. I used stable isotope and diet analysis to demonstrate that trophic position (TP) of three focal species differed at Lake Jackson, Leon County, Florida. The Florida cooter, *Pseudemys floridana*, was a specialist algivore (TP = 2.3), the yellow-bellied slider, *Trachemys scripta*, was a generalist omnivore (TP = 3.3), and the Florida softshell, *Apalone ferox*, was an omnivore with some specialization on insects and snails (TP = 3.8). I then performed a survey of turtle abundance and 18 biotic and abiotic habitat characteristics at 17 lakes in Leon County, Florida. Mantel analysis revealed that one of the best predictors of turtle abundances was periphyton. Abundances of all three focal species were strongly correlated with a mud and muck substrate and both top-down (no alligator predation) and bottom-up (high periphyton productivity) factors. On a finer scale, abundances of the individual species were correlated with additional factors that may be related to their trophic position: *T. scripta*, high phosphorus and high chironomid abundance, *P. floridana*, low macrophyte cover and high chironomid abundance, and *A. ferox*, high macroinvertebrate abundance, high snail abundance, and high phosphorus. The results of this study suggest that patterns of abundance of sympatric freshwater turtle species can be strongly influenced by environmental variables that are correlated with their trophic position in the food web. **SSAR SEIBERT ECOLOGY**

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A study on the learning and sensory capabilities of a captive *Manta birostris* (Mobulidae)

A female *Manta birostris* (4 m wingspan) was observed in the Lisbon Aquarium over an 18 day period during September 2004. Her presence in her feeding square, the position of the cephalic fins and surfacing behavior were recorded by the EthoLog softver before and during regular feedings, as well as at random times between feedings. These behavioral elements were also recorded to test the effects of (1) the presence of a person on a bridge above the feeding square, as well as (2) the empty feeding bucket, (3) a bucket not usually used for feeding, (4) shrimp soup and (5) normal feeding bucket with shrimp soup , each in the water separately. The *Manta's* normal behavior and her responses to these stimuli were also observed in another square of the tank, different than her usual feeding square. The results showed the presence of a person on the bridge didn't change her usual swimming behavior. However, the presence of the empty feeding bucket and the other bucket or the shrimp soup, all attracted her to the feeding square, where she spent more time and showed surfacing behavior in an attempt to feed. The most significant response was recorded after the empty feeding bucket was placed into the water at her feeding square. These results suggest that this *Manta birostris* has learned to appear in order to get her food in response not only to olfactory but visual cues as well. **AES CARRIER**

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Revisions of *Lasiancistrus* and *Peckoltia* sensu stricto

Two of the more confusing genera in the Loricariidae are *Peckoltia* and *Lasiancistrus*. *Lasiancistrus* has about 15 species currently from much of South America. A revision of *Lasiancistrus* has found that four of those species are valid (*L. castelnaui*, *L. caucanus*, *L. guacharote*, and *L. heteracanthus*), two are *incertae sedis* (*Ancistrus multispinis* and *Chaetostomus trinitatus*), and one is an *Ancistrus* (*L. nationi*). In addition, two new species need to be described. *Lasiancistrus caquetae*, *L. guapore*, and *L. scolymus* are synonyms of *L. castelnaui*, *L. maracaiboensis* and *L. mystacinus* are synonyms of *L. guacharote*, and *L. mayoloi*, *L. planiceps*, and *L. vulcanensis* are synonyms of *L. caucanus*. A wide range of species have been placed in *Peckoltia*, but the genus is not diagnosable by synapomorphies. However, there is a core group of *Peckoltia* with at least six described species and two undescribed species referred to as the *P. vittata* species group. This group includes the type species *P. vittata*, *P. braueri*, *P. brevis*, *P. cavatica*, *P. kuhlmanni*, and *P. vermiculata*. In addition, *Peckoltia bachi* (with synonyms *P. arenaria*, *P. filicaudata*, and *P. ucayalensis*) may be recognized as a unique genus. This genus was recently described as *Sophiancistrus* (type *P. ucayalensis*); however, *Peckoltichthys* is an older name (type *P. filicaudatus*). An up-to-date phylogeny for the Ancistrini will be provided, but has little resolution in the species of *Peckoltia* and its relatives.

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Controversies around basal actinopterygian relationships

An analysis of the available hypotheses shows that there is great disagreement in the relationships of basal actinopterygians. This is caused by different selection of taxa and different assumptions over homologies. The disagreements are clearly illustrated by major changes in the relationships of living polypteriforms, acipenseriforms, amiiforms, and lepisosteiforms to fossil forms and also to teleosts. Several hypotheses of sister-group relationship to teleosts have been proposed based on morphological evidence (e.g., mobile maxilla, presence of supramaxilla, position of symplectic). For instance: (other actinopterygians + [lepisosteids + [amiids + Teleostei]]); (other actinopterygians + [amiids + [lepisosteids + Teleostei]]); and (polypteriforms + [acipenserids + [[amiids + lepisosteids + Teleostei]]]). Molecular studies have not clarified the sister group of teleosts, but rather given uncompromising solutions, e.g., (polypteriforms + [acipenserids + [[amiids + lepisosteids] + Teleostei]]) and (polypteriforms + [[acipenserids + amiids + lepisosteids + Teleostei]]). Traditionally, polypteriforms and chondrosteans are interpreted as having a basal position in the palaeonisciforms; however, new evidence suggests that they could be more advanced than previously considered.

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A phylogenetic analysis of Batoidea (Elasmobranchii) based on morphological data

Although monophyly of the batoids (electric rays, sawfishes, guitarfishes, skates, and stingrays) is widely accepted and well corroborated, the interrelationships within batoids remain controversial. The most contentious issues concern the phylogenetic position of the Torpediniformes (electric rays) and the Pristiformes (sawfishes), and the composition of the Rhinobatiformes (guitarfishes). A phylogenetic analysis based on 81 anatomical characters of representatives of 32 of the 72 genera of batoids and four outgroups revealed that batoids comprise three major clades: Torpediniformes, Rajiformes, and Myliobatiformes. Rajiformes include Pristidae, *Rhina*, *Rhynchobatus*, Rhinobatidae, and Rajidae. Myliobatiformes include Platyrrhinidae, *Zanobatus*, and Myliobatiformes (in a traditional sense). The derived myliobatiforms comprise two major clades: *Gymnura* and the pelagic rays, and the benthic rays. The terminal benthic rays form two clades: 1) Indo-Pacific *Himantura*, New World *Himantura*, and potamotrygonids, and 2) *Dasyatis kuhlii*, *Taeniura*, *Pteroplatytrygon*, and *Dasyatis*. Neither *Himantura* nor *Dasyatis*, as presently conceived, are monophyletic. Several West African species of *Dasyatis* are more closely related to Indo-Pacific *Himantura* than to *Dasyatis*.

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Egyptian tortoise conservation: A field research program developed from a study on a semi-captive population

We devised an in-situ conservation and research program from a captive population of the globally endangered Egyptian tortoise *Testudo kleinmanni*. We examined the activity patterns and dietary preferences of 28 semi-captive Egyptian tortoises that were considered for possible reintroduction into Zaranik Protected Area (ZPA), North Sinai, Egypt. A goal of this study was to have someone from the local community be the research technician and collect all the data in order to utilize use their indigenous tracking skills and knowledge of the area. In order to overcome any problems with illiteracy, we created a data sheet based on symbols and numbers. The research on captive animals was part of a larger conservation program that included an educational outreach and craft program initiative, which eventually lead to the rediscovery of wild Egyptian tortoises in North Sinai, at which time was thought to be extinct. We have now shifted our focus to in-situ conservation, using the research and local capacity building template developed from this captive population study. We discuss how understanding the activity patterns and dietary preferences of the tortoises

assisted us in conserving wild tortoises. We believe our template can be used by zoos and conservation organizations with small budgets and native collections in natural habitats to create similar captive research programs that can be applied to in-situ conservation.

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Effects of vegetation loss on a sand dune lizard

We examined the effects of vegetation loss by livestock grazing and agricultural practices on the abundance of the lizard *Acanthodactylus longipes* in Sinai, Egypt. To investigate why *A. longipes* was less abundant in areas experiencing vegetation loss, we next compared body condition, thermoregulatory behavior, and activity patterns of lizards from unprotected (vegetation loss) and protected habitats. Individuals in unprotected habitats did not have lower body condition which suggests that they were not experiencing food shortage. We were also not able to detect any significant effects of vegetation loss on any of the thermoregulatory behaviors of *A. longipes*, which is most likely a result of this species predominantly using behavioral acclimation that are independent of vegetation, such as stilted at night substrate temperature and is therefore not impacted by a reduction in vegetation patches. We did however find that lizards in unprotected habitats were significantly further away from vegetation and moved for longer durations, which could potentially increase the visibility of individuals to predators. Any costs of moving more than individuals in protected habitats were not displayed in body condition. Our data suggest that vegetation loss may not impact the thermoregulatory behavior of lizards that thermoregulate independently of vegetation and that decreased abundance may be due to either lower carrying capacity or increased predation.

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Phenotypic and genetic divergence among disparate mtDNA lineages of spring peepers (*Pseudacris crucifer*)

Ongoing research on the intraspecific evolutionary history of *Pseudacris crucifer* shows significant range-wide phylogeographic structure and displays multiple areas of secondary contact. This pattern makes *P. crucifer* an ideal non-model vertebrate species with which to address questions on the relationship between genetic divergence and levels of reproductive isolation. We are characterizing one such contact zone in SW Ontario in detail (neutral genetic, and phenotypic characters including call structure, sperm morphology, and body proportions) and preliminary work suggests that there are phylogenetic differences in phenotypic characters. Ongoing work across other contact zones representing greater lineage divergences will permit the determination of the extent to which

gene flow is incomplete and, ultimately, the relative importance of pre- versus post-zygotic mechanisms underlying differentiation in *P. crucifer*.

***AVOLIO, CARLA**

Biological Sciences A08, University of Sydney, NSW 2006, Australia

Rough boys score better under the sea: Why it pays male snakes to be rugose in an aquatic environment

In several species of sea snakes (Family Hydrophiidae), males possess more rugose scales than do females. I quantified the nature and distribution of these rugosities in relation to sex, size, body condition, season and latitude in four species of sea snakes (genus *Astrotia*, *Emydocephalus*, *Hydrophis* and *Lapemis*) from museum collections. I also evaluated the functional significance of scale rugosities in the reproductive strategies (male-female interactions, male-male interactions and mate searching) of male turtle-headed sea snakes, *Emydocephalus annulatus*. Scale rugosities in this species may have multiple functions, including sensory feedback during courtship (tubercles were better innervated with myelinated nerves) and increased friction between the males and females at this time. Scale rugosity also affected boundary-layer characteristics in various flow regimes. Biomechanical analyses showed that shear stress was greater over models of male (rugose) skin than female (non-rugose) skin at water velocities typical of the speed of courting pairs, but this situation was reversed at higher flow rates (as seen in mate searching males). The greater turbulence over male skin at low flow may enhance gas exchange with the water at courting speeds, whereas the opposite situation at higher (mate searching) speeds may decrease drag force and hence, enhance swimming efficiency. Together, these results suggest that rugose scales in male sea snakes initially evolved to enhance grip and tactile sensitivity of body parts used directly in copulation, but have been elaborated to cover the entire body surface for hydrodynamic benefits. **SSAR SEIBERT EVOLUTION/SYSTEMATICS**

***AWRUCH, CYNTHIA A.; FRUSHER, STEWART D.; STEVENS, JOHN D.**

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Movement patterns of the draughtboard shark *Cephaloscyllium laticeps* using acoustic telemetry and conventional tagging

The draughtboard shark *Cephaloscyllium laticeps* (Duméril, 1853) is the most common catshark in coastal areas of southern Australia. We have been using a combination of acoustic and conventional tagging technology to provide a greater insight into the behavior of this species. Between January 2000 and February 2004, 375 conventionally tagged sharks were released in an isolated reef study site in the Derwent Estuary, Tasmania, Australia. To date, 121 sharks have been recaptured with 36% recaptured on multiple occasions. The large amount of multiple recaptures within the reserve suggests a high degree of site fidelity. Larger longer-term movements of up to 200km have been recorded. The longest

period between tagging and recapture was 39 months. Between January-July 2003, 25 sharks were fitted with acoustic tags. Acoustic receivers were deployed in the study site, along the Derwent Estuary and in an adjacent bay. Acoustic tag results also demonstrated the high affinity that draughtboard sharks have for the study site. The analysis of the acoustic data also provided information on residency periods and behavior that could not be obtained from conventional tagging studies. **AES CARRIER**

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Endocrine correlates of the reproductive biology of the oviparous catshark, *Cephaloscyllium laticeps* (Duméril, 1853)

The draughtboard shark *Cephaloscyllium laticeps* is an oviparous species that inhabits the coastal waters off Southern Australia where it is a common bycatch species in commercial trap, net and hook fisheries. We addressed the reproductive condition of this species based on the level of steroid hormones in the plasma. We tested four hormones, Estradiol (E2), Testosterone (T), 11-Ketotestosterone (11-KT) and Progesterone (P4). 11-KT was not detectable in any shark. T, E2 and P4 were present in females although P4 and E2 were only found in low concentrations in males. Correlations of reproductive development with the level of gonadal steroids were obtained and subsequently used to assess the maturity of sharks caught and released in a scientific reserve. Results from this study demonstrate that assessment of reproductive biology in elasmobranchs can be achieved without harm to the shark. The development of a non-destructive sampling technique has benefits for sampling sharks that do not need to be killed, such as endangered species, species in marine protected areas, nursery areas or bycatch species. This study has significant implications for future elasmobranch research and also advances our knowledge on endocrinology of marine fish. **AES GRUBER**

***BALL, JAMES C.; BOGART, JAMES P.; MCCUISTION, MICHAEL C.**

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A survey of breeding salamanders in Cass County, Michigan:
Identification of two new hybrid genotypes of the *Ambystoma laterale* complex

In 2003 and 2004, 398 salamanders were trapped from ten suitable breeding sites using enlarged, unbaited minnow traps. Three species were captured during the early spring breeding season: Blue-Spotted Salamanders (including the *Ambystoma laterale* complex); Spotted Salamanders, *Ambystoma maculatum*; and Tiger Salamanders, *Ambystoma tigrinum*. No Eastern Newts, *Notophthalmus viridescens*, were captured. All salamanders were anesthetized using MS-222 and

the snout-vent length, total length, and mass were measured. In the case of salamanders of the *A. laterale* complex the ploidy levels were determined using flow cytometry and the nuclear genomes of 81 hybrid *A. laterale* complex salamanders were determined by allozymes. In addition to several previously known genotypes that have involved genomes of *A. laterale*, *A. jeffersonianum*, *A. texanum* and *A. tigrinum*. identified in these populations, two new genotypes were discovered in this current survey. These new hybrids were a diploid *A. laterale-tigrinum* (LTi) and a triploid *A. (2) laterale-tigrinum*.

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Using hemipenis characteristics to determine the correct classification of Dipsadinae *incertae sedis*

The hemipenes of the species comprising the group Dipsadinae *incertae sedis* are described and illustrated. Analysis of hemipenis characters (position of the origin of the retractor muscle, hemipenis length, number of spines, number of spine rows, and the position of the distal end of the spinose midsection of the hemipenis) was conducted to determine the variance within and among the species. Previous systematic study of the species in this group has not yielded reliable placement in a Colubrid subfamily. Therefore detailed investigation of hemipenial characters may enable such placement and should prove useful for future systematic work.

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Habitat use of juvenile slider turtles (*Trachemys scripta*)

Life history studies often detail ontogenetic changes such as differences in habitat use. Several freshwater turtle species exhibit marked differences in habitat use patterns across ages and sizes. However, little is known about the juvenile class of the widely studied red-eared slider (*Trachemys scripta*). Because *T. scripta* is ubiquitous in habitat occupancy as adults, survival pressures on juveniles may result in a marked comparative shift in habitat. We investigated differential habitat use in a population of *T. scripta* from a floodplain lake located in Gallatin County, Illinois. In our initial year of study, we used 25 baited hoop traps for 26 days and all *T. scripta* captured were aged, measured, and sexed. At each trap location we measured water depth, distance from shoreline, canopy cover, presence/absence of logs, presence/absence of bushes, and bank slope for comparison among age classes. Many of our results indicate that more sampling effort will be required to determine if there are trends present. We plan to augment sample sizes by trapping a wider span of habitats and with double the number of traps in the upcoming season.

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Ambush site selection in a generalist forager, the Western cottonmouth (*Agkistrodon piscivorus leucostoma*)

Ambush site selection plays a crucial role in the foraging success of ambush predators. We characterized the nocturnal ambush sites of a prey generalist, the Western cottonmouth (*Agkistrodon piscivorus leucostoma*), in a stream/pool system in Hardin Co., Tennessee. Ambushing snakes (n=30, immobile at site for >15 min) were located between 2100-0500 h. Habitat features were recorded at the ambush sites as well as at four distinct sites at a distance of 2 meters from the ambush sites. These random sites were determined using the four compass points and were used as potential sites that were not selected by the snakes. Recorded habitat features included aquatic versus terrestrial habitat, cover, water depth, grass density, distance to/from shore, water flow, distance from wood structure (with >2 cm diameter) and presence of aquatic support. Sex, mass, SVL and TL were recorded after capture, and snakes were paintmarked to avoid in recapture. The importance of prey availability in site selection was examined as well. Ranid frog density surveys were conducted while walking an 800 m transect of stream/pool shoreline at night, recording the number of frogs sighted, flushed or heard calling within 2 m of the stream. Ambush site selection by *A. p. leucostoma* was non-random. Ambush sites differed from random sites in water depth and degree of cover (snakes selected shallower water and greater cover), but not in distance from wood structure or aquatic versus terrestrial habitat. Cover may aid in crypsis of snakes, both from predators and prey, while shallow water may increase the probability of successfully seizing prey. Frog density was shown to have a positive correlation with site selection. Thus, ambush site selection may be proximately cued by both abiotic and biotic factors, and the adaptive significance of this choice may be in its effect on nutrient intake.

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Differences in the ratios of fin to carcass weight among fourteen species of sharks

The practice of shark finning, or the harvest of a shark's fins without the carcass (meat), was prohibited by federal law in 1993. To regulate and minimize shark finning, federal rules were enacted that allowed fins to be landed if the total weight of the fins was no more than five percent of the total weight of the landed dressed carcasses. Although many different species are harvested for their fins,

the "five percent rule" was established using data from only sandbar sharks, *Carcharhinus plumbeus*, due to a lack of data for other shark species. Fin weight ratios were calculated for several commercially valuable shark species from coastal waters of the U.S. Atlantic Ocean and Gulf of Mexico using standardized data collated from state and federal databases. Analysis of variance procedures, Scheffe's multiple comparison analysis, and student's t-tests were used to test for statistical differences in the fin weight ratios of 14 species of sharks. Comparisons were made among species for which comparable size data were available; therefore large coastal and pelagic sharks were analyzed separately from small coastal sharks and dogfishes. The fin weight ratio of the sandbar shark (5.33%) was the largest of the 14 species examined, while the silky shark, *Carcharhinus falciformis*, exhibited the lowest ratio at 2.53%. The fin ratio of the sandbar shark was significantly higher than most of the other large coastal species we examined, and the bonnethead shark, *Sphyrna tiburo*, had a fin weight ratio (4.91%) that was significantly higher than other small coastal species examined. Fin ratios were not different between juveniles and adults for most species, suggesting an isometric growth relationship. The variation in ratios among the species we examined suggests that species-specific management of shark finning in U.S. waters should be further explored. **AES GRUBER**

BARICHIVICH, WILLIAM J.

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Factors affecting Southern Leopard Frog, *Rana sphenoccephala*, distribution and detection in five coastal plain refuges

The Department of Interior Amphibian Research and Monitoring Initiative (ARMI) began in 2000 with the goal of evaluating the status and trends of amphibian populations throughout the United States. The southeastern region includes Alabama, Florida, Georgia, North and South Carolina, and Tennessee. Much of the SEARMI effort has been focused on five Gulf and Atlantic Coastal Plain U. S. Fish and Wildlife Service National Wildlife Refuges: Harris Neck, Lower Suwannee, Okefenokee, St. Marks and Savannah. To date, we have recorded 6,500 individual observations of 36 species of amphibians on these refuges. The Southern Leopard Frog, *Rana sphenoccephala*, occurs on all five sites and accounts for approximately 10% of our records. Although many species of amphibians are restricted to certain aquatic habitat types for breeding based on abiotic or biotic characteristics, we have observed *R. sphenoccephala* larvae and adults in the presence and absence of vertebrate and invertebrate predators and in wetlands with ephemeral to permanent hydroperiods. The physical parameters of breeding sites ranged widely with pH (3.62-7.77), dissolved oxygen (0.56-13.1 mg/L), conductivity (0.014-0.808 ms/cm), and temperature (9.21-32.49°C). Although seemingly an obvious candidate for monitoring due to its ubiquitous distribution and apparent abundance, the Southern Leopard Frog is so much of a generalist that meaningful covariates that might help explain its presence or absence in a percent of area occupied analysis are challenging to define. Understanding the factors that influence the abundance and detection of this widespread amphibian may help us develop methods and protocols for other amphibian species that are in decline.

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A minisatellite in the growth hormone gene of Esocidae is derived from a single copy element in the salmonid genome

The growth hormone gene has been used to infer phylogenetic relationships in fishes, and in closely related species the intronic sequence has shown particular value in discriminating among taxa. To utilize this approach for the esocid family, we first cloned the genomic copy of the growth hormone gene from *Esox masquinongy* and subsequently the fourth intron from the four remaining esocid species. Our initial analysis identified a 33-nucleotide minisatellite in the fourth intron that is present in copy numbers ranging from 7 to 16 among the various species. Database searches indicate that this minisatellite is present only as a single copy element in all of the salmonids, indicating a recent expansion in the *Esox* species since their divergence from a common ancestor. The minisatellite was not detected in any other growth hormone sequences available at the time of this writing. Furthermore, point mutations and deletions in the esocid minisatellites indicate a model for the evolution of this genetic element and corroborate existing molecular phylogenies for the five members of this genus.

***BARRIBEAU, SETH; WALDMAN, BRUCE**

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Kinship association reduces the growth inhibitory effects of the pathogen *Aeromonas hydrophila* on *Xenopus laevis* tadpoles

We examined the effects of crowding, kinship composition, and habitat complexity on the growth and survival of *Xenopus laevis* tadpoles exposed to the bacterial pathogen *Aeromonas hydrophila*. Pathogens increasingly are contributing to amphibian population declines, so we need to understand the factors that predispose amphibians to infection. Crowding, kin composition, and habitat complexity ('psychological space') have been linked to tadpole growth. We examined how these factors influence tadpoles' disease resistance. Tadpoles were raised with just siblings or in mixed kin groups, in crowded or uncrowded conditions, and in simple or physically partitioned (complex) habitats. Under these regimens, tadpoles were exposed either to *A. hydrophila* or to a sham inoculum. We found that tadpoles' growth rates decreased and became more variable as a function of density, exposure to *A. hydrophila*, rearing with non-kin, and increased habitat complexity. Tadpoles in pure sibling groups grew larger than those reared in mixed groups, but this difference was most pronounced when tadpoles were exposed to *A. hydrophila*. Differences in growth rates between sibling and mixed groups decreased in crowded conditions. Size differences between exposed and control tadpoles were greater in low-density than in high-density treatments. Mixed kinship composition and high tadpole density may increase competition and thus reduce growth. Our results suggest that growth is inhibited by exposure to pathogens but that this effect may be ameliorated by reduced competition within sibling groups. Schooling with kin may reduce tadpoles' vulnerability to infection.

***BARRIBEAU, SETH; WALDMAN, BRUCE**

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MHC and disease resistance in *Xenopus laevis* tadpoles

Given recent cataclysmic amphibian declines, understanding the mechanisms involved in disease resistance is becoming increasingly urgent. The Major Histocompatibility Complex (MHC) is an integral part of the vertebrate adaptive immune system and has been well characterised in *Xenopus laevis*. To elucidate the importance of the MHC in conferring disease resistance, we challenged *X. laevis* tadpoles, with known combinations of MHC alleles, to lethal and sublethal doses of *Aeromonas hydrophila*. This ubiquitous bacterium, although commonly associated with 'red leg' in frogs, tends to affect already immunocompromised individuals. We exposed tadpoles of six MHC types, three homozygous and three heterozygous, to *A. hydrophila* that we had isolated from sick frogs, and measured the tadpoles' growth and developmental rates. Initial results indicate that MHC type significantly affected development and growth, although there was no interaction between MHC type and exposure dose. Homozygotes developed more rapidly than heterozygotes and certain MHC types consistently developed faster than others and were more susceptible to the pathogen. There was no difference in survival between heterozygotes and homozygotes. While the absence of heterozygote advantage is expected when a single challenge pathogen is used, the presence of an *A. hydrophila* 'weak' MHC type illustrates the importance of maintaining population-level genetic diversity at the MHC among at-risk species.

BART, HENRY L. JR.; *CLEMETS, MARK D.; DOOSEY, MICHAEL H.; HURLEY, DAVID L.

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Utility of the growth hormone gene for estimating phylogenetic relationships among cypriniform fishes

Studies suggest that single-copy, protein-coding nuclear genes are effective for estimating deep divergences in organismal phylogenies and thus can help investigators avoid pitfalls associated with use of only mitochondrial genes for phylogeny reconstruction. The growth hormone gene (GH) is a single chain, pituitary specific hormone that is essential for promotion and maintenance of somatic growth in vertebrates. A number of GH coding sequences are available for fishes and studies have shown that GH is an excellent locus for deep phylogenetic inference. In fishes of Order Cypriniformes, GH comprises 5 exons, and 4 introns and codes for a protein of approximately 220 amino acid residues. In this paper, we use sequences from both exons and introns to demonstrate the utility of the GH gene for resolving relationships among select cypriniform taxa, representing all families and a number of the currently recognized subfamilies. The analysis resolves Order Cypriniformes as monophyletic with high bootstrap support. Catostomids are also monophyletic and sister to cyprinids. This group is sister in turn to Gyrinocheilids plus cobitoids. GH coding sequence divergence

among cypriniform families ranges from 12-15% and shows little evidence of saturation or loss of phylogenetic signal, even at the third codon position. Introns are more variable and useful for resolving relationships at more superficial levels within the cypriniform phylogeny. We demonstrate the utility of intron data for examining relationships at and below the genus level in Family Catostomidae. We compare phylogenies based on GH to those based on morphology and mitochondrial DNA sequences.

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Patterns of sequence variation in introns of the growth hormone gene in species of *Ictiobus* (Cypriniformes: Catostomidae)

Genus *Ictiobus*, as currently recognized, comprises four or five species of suckers commonly referred to as buffalofishes. Species in the genus are morphologically distinct, widespread geographically (Hudson Bay system of Canada to Rio Usumacinta in Guatemala), and have a fossil record dating to the lower Pliocene. Previous work indicates that, with the exception of *Ictiobus labiosus* of central Mexico, cyt b sequence divergences among *Ictiobus* species are very low and inconsistent with morphological variation. The pattern of cyt b sequence variation suggests either low rates of substitution, recent speciation, introgressive hybridization, or a combination of these factors. In order to gain a deeper understanding of the factors contributing to this pattern, we sequenced introns of one of two paralogous copies of the nuclear growth hormone (GH) for specimens from throughout the geographic ranges of currently recognized *Ictiobus* species. GH introns exhibit higher sequence divergences and patterns of variation generally more consistent with morphology than cyt b. However, the GH intron data also show evidence of past and present interspecific hybridization and recent establishment of current geographic distributions of species in the genus. The results suggest decoupling of morphological variation from patterns of variation in both mitochondrial and nuclear genes.

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Computerization, recuration, and inventory of the Tulane University Museum of Natural History fish collection

The Tulane University Museum of Natural History (TUMNH) Fish Collection, one of the largest collections of post larval fishes in the world, has been undergoing curatorial improvements since 1994 with support from the Biological Research Collections program at the National Science Foundation (NSF). The project is currently in the third and final phase. The goals of the project were to completely computerize and georeference collection records, recurate the

collection, and inventory the holdings against the collection database. All jar lots in the collection are being transferred from 50% isopropanol to 70% ethanol. In the process, experiments are being conducted to assess the long-term effects of preservation in the two types of alcohol on specimen quality. To date, approximately 90% of the collection has been recurated and inventoried. The collection records are completely computerized, georeferenced and accessible over the Internet. The georeferenced data were use as a test bed to develop an automated georeferencing tool (GEOLocate) which is enjoying wide use in the natural history collection community. The preservation experiments suggest that ethanol is superior to isopropanol for long-term specimen quality. Every summer since 1996, we have been employing minority high school students from the New Orleans Center for Science and Mathematics as curatorial interns with support from the Research Assistantships for Minority High School Students (RAMHSS) program at NSF. supplements since 1996, to involve minority high school students in the collection improvement tasks.

***BASIoTIS, KATHERINE A.; MUSHINSKY, HENRY R.; MCCOY, EARL D.**

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Do gopher tortoises (*Gopherus polyphemus*) consume exotic cogongrass (*Imperata cylindrica*)? Results of a feeding experiment

The gopher tortoise (*Gopherus polyphemus*) is considered a keystone species because individuals dig burrows that provide shelter and refuge not only for themselves but for numerous commensal organisms, including several protected species. The gopher tortoise is federally listed as threatened in much of its range beyond Florida, and is a species of special concern within Florida. Habitat loss due to rapid development is the greatest threat to the gopher tortoise. A relatively new threat to the persistence of gopher tortoise populations may be the highly invasive cogongrass (*Imperata cylindrica*). This study documented the threat of an expanding monoculture of cogongrass to a population of relocated gopher tortoises in central Florida. The study site was located within the Teneroc Fish Management Area in Polk County, Florida. The first part of the study consisted of a series of feeding experiments conducted in the field. Tortoises were trapped using bucket traps placed outside burrow entrances. Captured tortoises were placed in a holding pen near their burrows for one hour to stabilize their behavior. Cogongrass previously transplanted to a pot was placed in front of the tortoise for an additional three hours to determine absolute preference. The experiment was repeated with two control groups, presenting either *Aristida*, a negatively selected native wiregrass, or green lettuce, a food highly favored by captive tortoises, in place of the cogongrass. The data gathered will be incorporated into a larger study including experiments investigating the effect of cogongrass on the homing and orientation abilities and habitat use of the tortoises. For a number of reasons the spread of the invasive grass effectively reduces the tortoises' habitat, compounding the threat of anthropogenic habitat destruction to this threatened keystone species.

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Seeking caeca: Loss of pyloric caeca - a siluriform gut synapomorphy associated with an animal diet

A survey feeding habits, gut morphology and some preliminary gut histology of siluriforms and related groups reveals synapomorphic conditions of coiling, a possibly pedomorphic lack of coiling and a synapomorphy of the catfish clade, the apparent complete lack of pyloric caecae. Pyloric caecae are wide spread among fishes, both animal and plant feeders, and greater numbers of them are generally considered to be associated with herbivory. The apparent loss of pyloric caecae in the hypothetical ancestral catfish is hypothesized to be a manifestation of a fundamental commitment to feeding on animal material, which when reversed in the very few siluriform plant feeding groups, namely the loricariids, is not accompanied by the reappearance of pyloric caecae. Rather, the Loricariidae is well known for having developed an extreme degree of intestinal coiling.

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Grinding the millstone: Evolutionary divergence within the ocean sunfish, Molidae (Tetraodontiformes)

Ocean sunfish, family Molidae, are enigmatic members of the epipelagic fauna of all tropical and temperate oceans. Although the species *Mola mola* holds the Guinness World Record for the most fecund of fishes, with an estimated 300,000,000 ova found in one female, even a basic understanding of their natural history is lacking. Some research has focused on the systematic relationships among the Tetraodontiformes, including Molidae, but little is known about the population genetics of many of the species in the family or their evolutionary history. We have been studying the population biology and genetics of the ocean sunfish, *Mola mola*, and present phylogeographic and systematic inferences gained from DNA sequences of the control region of the mitochondrial genome of this globally distributed species. Preliminary findings indicate strong population structure between, and to a lesser degree within, ocean basins. During our investigations we have also discovered a cluster of deeply divergent lineages and here we argue for the systematic distinctiveness of this group based on previous species descriptions and geographic distributional information. Additionally, we examine the systematic relationships between members of the family Molidae, including *Ranzania laevis* and *Masturus lanceolatus* using data from the cytochrome b gene. We have found strong support for the traditional hypothesis regarding the sister taxa relationship between *Masturus* and *Mola* and the basal position of *Ranzania* within the family.

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An Eocene gecko in Baltic amber: Implications for gekkotan evolution

A new genus and species of gekkonid lizard is described from the Lower Eocene of northwestern Russia based on a specimen preserved in Baltic amber. The digits of the manus exhibit a combination of characters not present in any living or fossil group of geckos, but the absence of osteological data from the specimen precludes even tentative phylogenetic placement at this time. The specimen represents the first and only record of a gecko from Baltic amber, the oldest amber-preserved gecko, and the first gecko in amber not assignable to a living genus. The foot of the amber gecko has well-developed subdigital lamellae that are indicative of a complex adhesive system comparable to that of living geckos. This places the minimum age of the evolution of scansorial toes in geckos at approximately 54 million years. Like all other amber-preserved geckos, the new taxon is minute and was probably similar in ecology to *Lygodactylus* spp., the most commonly encountered gekkonid in copal, a more recent plant resin that has yielded many lizard inclusions.

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Experimental analysis of allocation patterns in ambystomatid salamanders

Ontogeny of *Ambystoma tigrinum* and *A. maculatum* were manipulated in order to test the hypothesis that metamorphic timing, metamorphic size, and expression of paedomorphosis are affected by light, growth rate, and temperature. Fat bodies and gonads were removed, scored, and weighed to detect allocation toward sexual development in order to assay paedomorphosis. Identical treatments were imposed for each species to contrast the treatment effects on metamorphic timing in both an obligate metamorph and a facultative paedomorph. Low temperatures resulted in increased metamorphic size and extended larval periods in both species. Increases in food led to increased gonad development. Reduced food led to increased larval periods in both species. Light did not play a significant role in any allocation variable. determining SVL or metamorphic mass. Analysis of allocation to storage, gonads, and metamorphic development supports that notion that facultative paedomorphosis is a feature that is contingent upon environment context. For example, tradeoffs predicted to lead to paedomorphosis are only exhibited in low temperature, low food condition and only in *A. tigrinum*. Thus, there are species-specific differences in allocation patterns that make one species more likely than another to express a paedomorphic life cycle.

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Highs and lows in salamander evolution: Phylogenetics of coastal plain dusky salamanders

The morphologically-conservative plethodontid genus *Desmognathus* has proved repeatedly problematic for herpetologists examining its species-level systematics. Although recent molecular phylogenies have helped resolve relationships among montane forms, species from the coastal plain have been largely ignored. *Desmognathus* is widespread in both Atlantic and Gulf coastal plains and three species *Desmognathus auriculatus*, *D. conanti*, and *D. apalachicola* are currently recognized. However, equivocal species assignments (e.g., *D. auriculatus* vs. *D. conanti*) persist for several populations over broad geographic areas. To clarify relationships among coastal plain *Desmognathus*, we sampled 40 populations from North Carolina to Louisiana and analyzed mitochondrial COI variation for 120 individuals. High levels of sequence divergence suggest more than three species occur in the coastal plain. For example, we documented within drainage sympatry along the Tar River for two undescribed forms historically considered to be *D. auriculatus*. Bayesian inference suggests that the coastal plain likely experienced multiple invasions of ancestral montane *Desmognathus* and that certain coastal lineages have reinvaded montane settings.

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Potential consequences of the coqui frog invasion in Hawaii

The introduced Puerto Rican frog, the coqui (*Eleutherodactylus coqui*), threatens Hawaii's multi-million dollar floriculture, nursery, and tourist industries as well as its unique ecological systems. Using data from Puerto Rico and preliminary data from Hawaii, we suggest likely consequences of the invasion and future areas of research. We expect the greatest impact will be reductions of Hawaii's native arthropods, even though the majority of their diet consists of non-native species. Because native birds are mostly restricted to high elevation forests, there is currently little overlap between coqui and native bird habitats or diets. Furthermore, preliminary data suggests that coquis will not bolster introduced mammal populations, well-known native bird predators. However, coquis may change lowland ecosystems, where the majority of their populations are found, in such a way that native bird re-invasion into these areas would be more difficult. For example, coquis appear to be controlling arthropod prey and increasing nutrient cycling rates, which can alter plant species composition. In summary, research from Puerto Rico and preliminary data from Hawaii suggests that coquis will change community and ecosystem properties where they invade. The ability for other invasive amphibians to have these effects should not be overlooked. Citric acid spraying has curtailed coqui invasion in Oahu and Kauai; however, repeat spraying is necessary to ensure complete eradication and should be complemented with the removal of habitat structure. We will present preliminary data from the first study to determine the impacts of citric acid

spraying on coqui population dynamics. This research is relevant to other parts of the world because coqui invasion into other areas is mostly a matter of time.

BEAUMAN, RICHARD L.

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Factors affecting degree of burrow collapse and resulting tortoise self excavation and behavior

The Gopher Tortoise is a federally listed species in the western portion of its range, and a species of concern elsewhere. Their burrows are often collapsed and tortoises become entombed during human activity associated with logging activity and land use. Little is known to what extent burrows collapse, what factors contribute to the degree of collapse, how this impacts the tortoises' ability to self excavate after the collapse, and what effect this has on movement behavior. As part of a larger study to determine how physiologically detrimental this disturbance is to tortoises, we documented the physical factors that impact the degree of the collapse and monitored pre collapse and post excavation movement behavior. In the spring of 2004, we experimentally collapsed active burrows with tortoises in them using a piece of forestry equipment. The burrows were collapsed near their mouths with a JD 648 logging skidder (n = 22). We measured the collapse zone and monitored the number of days until each tortoise self excavated. The collapsed zone ranged from 0.66 to 2.21m and the amount of time to self excavation ranged from hours to 85 days. The majority of tortoises excavated within 20 days. The distance from the original mouth to the point of exit on self excavation ranged from 0 to 3.05m. There was a significant positive correlation between the amount of burrow collapse and the exit distance from the original mouth. There was no significant difference between the number of burrows used, the number of times moved or the size of the home range pre and post collapse. Upon self excavation, tortoises stayed in the collapse burrow (50%), moved to a previously used burrow (4.5%), or moved to a new burrow (45.5%). This and other aspects of movement behavior will be discussed.

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Long-term responses of Timber Rattlesnakes (*Crotalus horridus*) to food augmentation.

Bioenergetic modeling and observational studies suggest the primary importance of food availability in determining growth and body condition of low-energy adapted pit vipers. Since 1998, I've conducted a long-term supplemental feeding experiment with Timber Rattlesnakes (*Crotalus horridus*) in the Ozark Mountains of northwest Arkansas. A large sample of radiotagged snakes has been divided into a control group (CON, which feeds naturally) and a supplemental group (SF, offered feeder rats). I've monitored several response variables, including growth rate, body condition, and reproductive behavior. In general, SF animals exhibit significantly greater growth rate, increased body condition (residuals of mass-SVL regression) and increased rates of reproductive behaviors. Significant differences among years in the magnitude of the effect of supplemental feeding

result from annual variation in food availability to CON animals. An exceptionally poor food resource year (2004) resulted in the greatest differences between SF and CON treatments. CON snakes are subjected to increased mortality during food-poor years due to starvation and a willingness to adopt risky strategies (foraging late into Fall). Food-poor years result in increased mortality when snakes are caught by hard frosts in November or December. For a variety of reasons, it is unlikely that supplemental feeding will become a useful technique for the remediation of endangered populations. However, growth rates and body condition of Timber Rattlesnakes respond rapidly to changes in food resource availability, making these animals potentially useful for bioassessment.

***BELL, KRISTEN E.; DONNELLY, MAUREEN A.**

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Influence of forest fragmentation on community structure of frogs and lizards in lowland Costa Rica

We examined community and population structure of frogs and lizards in the fragmented landscape surrounding La Selva Biological Station in the Sarapiquí region of Costa Rica. Frogs and lizards were sampled in nine forest fragments (1-7 ha each) and La Selva (1600 ha) using diurnal leaf-litter quadrats and nocturnal transects; all sites were sampled monthly between October 2003 and August 2004. Species richness in all fragments (pooled) was 82% of that found in La Selva with comparable sampling effort. Richness varied from 10 to 24 species among forest fragments, compared to 36 species at La Selva. Frogs and lizards responded differently to fragmentation: lizard density was higher and frog density lower in fragmented patches than in continuous forest. Community composition varied among sites and by fragment size class. Species occurrence was nested with respect to fragment area. Between 18 and 25% of species we sampled in continuous forest were absent from forest patches. Such fragmentation-sensitive species may not survive outside continuous forest, while some lizards and other fragmentation-tolerant species remain abundant in forest fragments. Nevertheless, the high diversity observed in the entire set of fragments indicates that preserving a network of small forest patches may be of great conservation value to the herpetofauna of the Sarapiquí region. **SSAR SEIBERT CONSERVATION**

**BELL, KRISTEN E.; WHITFIELD, STEVEN M.; SASA, MAHMOOD;
*DONNELLY, MAUREEN A.**

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Population variability of a leaf-litter herpetofauna at La Selva, Costa Rica: Seasonal and long-term trends

We compared population densities of leaf-litter amphibians and reptiles across 35 years at La Selva Biological Station, a lowland wet forest site in Costa Rica. La Selva has received more attention from herpetologists than nearly any other

Neotropical site, and because researchers use a standard sampling method, this site provides a unique opportunity to compare quantitative data on populations over time. Our objectives were to determine whether patterns of seasonal abundance at La Selva are consistent across years, to assess changes in density and relative abundance of amphibians and reptiles over the last four decades, and to compare these changes between amphibians and reptiles to see if they support the hypothesis of amphibian declines. Seasonal abundance patterns were examined for 1973-74 (13 months) and 2003-04 (6 months). In 1973-74 there was a large peak in abundance for most species in March and April, corresponding to the end of the dry season; this peak was absent in 2003-04, and overall densities were an order of magnitude lower than those in 1973-74. Mean monthly densities were calculated for at least two months from each of the following years: 1970, 1971, 1974, 1990, 2000, 2003, and 2004. Most common species of both frogs and lizards in this assemblage demonstrated significant decreases in density over the 35-year period. Members of this assemblage depend on a similar set of habitat and dietary resources, which may explain the similar response across taxa. Our data do not support the hypothesis of an amphibian-specific decline at this site, but may either indicate widespread faunal declines or add to our knowledge of natural population fluctuations of tropical herpetofaunas.

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Development and evolution of lateral plate position in threespine stickleback: Developmental constraint or natural selection?

Lateral plates are bony armor structures of threespine stickleback, *Gasterosteus aculeatus*. The ancestral complete plate morph has 32-36 plates, with one per myomere, but plates are restricted to the first ten myomeres and number from zero to about ten in low morphs. We scored the myomeres on which plates occur in larval specimens from populations with high adult plate counts (complete and low morphs) but incomplete plate development, and in adult low morphs with a range of plate counts. During ontogeny, lateral plates usually develop first on myomere six, and the second plate is usually added on myomere five. Additional plates are added alternatively in front of or behind these first two plates, maintaining the median plate position of about six until the adult plate complement develops. Most adult low morphs have plates on the same myomeres as corresponding ontogenetic plate number phenotypes from populations with higher adult plate number phenotypes. There is a roughly inverse relationship between plate addition during plate development and plate loss during evolution. Thus, the pattern of plate loss during evolution of lower plate-number phenotypes represents paedomorphosis and might reflect developmental constraint. However, the last plates lost during evolution are the most important ones to stabilize the dorsal spines for defense against predatory vertebrates. Thus, it is possible that natural selection independently favors both early development and retention during evolutionary reduction of the most important plates for predator defense. Selection for a developmental pattern that increases defense function during plate ontogeny in larval stickleback may contribute to canalization of plate development.

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What makes and breaks cartilaginous jaws: The biomechanics and biochemistry of shark jaw cartilage

All vertebrates begin with a cartilaginous skeleton in the embryonic stage. As they mature, most convert their cartilaginous skeletons into bone. However Chondrichthians (sharks, ratfish, and rays) maintain a cartilaginous skeleton and thrive in the same niches as bony fish. In most vertebrates cartilage is a soft connective tissue that serves two purposes; a low-friction bearing surface and contour filler. Fish with cartilaginous skeletons can function at extremes (growing big, swimming fast, and eating hard-prey) which suggest that the skeletons of these animals are stronger than originally assumed. We also believe that the biochemical properties (collagen, proteoglycan, and water contents) affect the mechanical properties of the cartilage. We examined the biomechanics and biochemistry of shark jaw cartilage from four shark species; *Carcharhinus falciformis*, *Carcharhinus plumbeus*, *Sphyrna zygaena*, and *Isurus oxyrinchus*. Multiple 8.0 mm or 10.0 mm cylindrical plugs were tested by compressing the plug three times to ten percent of its initial thickness ($=0.10$) at 2 mm/sec. Properties differed between species ($p < 0.001$). Shark cartilage was also stiffer than mammalian cartilage (5.2×10^7 vs. 2.0×10^7 Pa). Shark and mammalian cartilage was similar in strength. The plugs were lyophilized and collagen and proteoglycan was measured with hydroxyproline and DMMB assays. The average value for water content was consistent with mammalian cartilage (85% vs. 75%). Collagen content was much lower than mammalian cartilage (13% vs. 50% DW). Further biochemical studies will investigate why shark jaw cartilage, which has very little collagen content, is as strong as mammalian cartilage.

BENARD, MICHAEL F.

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Survival trade-offs between two predator-induced phenotypes in Pacific treefrogs (*Pseudacris regilla*)

In many organisms, specific predator species induce defensive phenotypes in prey that are qualitatively different from the phenotypes induced by other predator species. This differential induction implies that there is no optimal phenotype that works best against all predators. However, few studies actually test if each predator-induced phenotype provides the highest survival rate in encounters with the predator that induced that phenotype. In this experiment, I reared pacific treefrog (*Pseudacris regilla*) larvae with chemical cues from two different predators (bluegill sunfish and predaceous diving beetle larvae), and without predator cues. The pacific treefrog larvae in the three treatments differed in their morphology and foraging behavior. I then exposed tadpoles from each treatment to free-foraging predaceous diving beetles and bluegill sunfish. Tadpoles survived best when exposed to the predator whose cues they were reared with, and worst when exposed to the other predator. In both predator environments, the tadpoles reared in the non-predator control treatment had

intermediate survival between the two predator-induced groups. Thus, there is no generalized 'antipredator' response to these predators; rather, there was a clear trade-off in survival abilities between the predators. **SSAR SEIBERT ECOLOGY**

***BENDIK, NATHAN F.; CHIPPINDALE, PAUL T.; GLUESENKAMP, ANDREW G.**

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Rapid radiation in central Texas neotenic salamanders and the systematic status of the Comal blind salamander, *Eurycea tridentifera*

The neotenic plethodontid salamanders of Central Texas include groups that have undergone rapid diversification, and display remarkable morphological variability associated largely with cave versus surface habitats. These rapid radiations, coupled with evidence of morphological convergence on habitat-associated morphotypes, make fine-scale phylogenetic inference problematic. *Eurycea tridentifera* is a state-protected cavedweller whose systematic status remains uncertain despite repeated efforts to resolve its relationships with other closely related Texas *Eurycea* ("southeastern", i.e., Blepsimolge clade). Previously, relationships among populations of *E. tridentifera* have been inferred largely based on limited molecular and morphological data. However, monophyly of this species was not well supported, and populations known as *E. tridentifera* could represent convergence to a cave-morphotype which formerly surface populations evolved when they became confined to subterranean habitats. Because the radiation within Blepsimolge is relatively recent, we used fast-evolving molecular markers to reconstruct the evolutionary history of this group. Here we present analyses of sequence data from the mitochondrial control region and other genes for putative populations of *E. tridentifera* plus other species, including numerous recently discovered populations. We test whether the populations identified as *E. tridentifera* (based primarily on morphology) form a monophyletic group, and resolve species boundaries and fine-scale relationships within the Blepsimolge clade of Texas *Eurycea*.

BERENDZEN, PETER B. Z.

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Phylogeography of the Bigeye Chub, *Hybopsis amblops* (Teleostei: Cypriniformes)

Periodic climatic fluctuations during the Pleistocene are thought to have played a major role in shaping the diversity and distribution of freshwater fishes in the Central Highlands of eastern North America. The bigeye chub, *Hybopsis amblops*, is one member of the Central Highlands fauna with a widespread, disjunct distribution in the Mississippi River Basin. This study presents a phylogenetic and demographic analysis of *H. amblops* using complete mitochondrial cytochrome *b* gene sequences for one-hundred and two individuals from twenty-

four populations across the range of the species. The objective was to identify patterns of genetic variation across the range of *H. amblops* and use these patterns to assess the roles of dispersal and vicariance in shaping the present diversity and distribution within the group. The phylogeographic patterns exhibited by *H. amblops* are compared to patterns observed in other taxa. The results reveal deep divergence between populations east and west of the Mississippi River and patterns of demographic expansion consistent with glacial cycles. Populations in the Ozark Highlands are estimated to have expanded during the interglacial period following the pre-Illinoian glaciations and populations in upper Ohio River drainage are estimated to have expanded following the most recent Wisconsin glaciation. **STOYE GENERAL ICHTHYOLOGY**

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What is critical habitat? The case of the Jefferson Salamander

The purpose of this study was to test whether the presence of Jefferson Salamanders (*Ambystoma jeffersonianum*), Blue-Spotted Salamanders (*Ambystoma laterale*), and their associated polyploid unisexuals in Southern Ontario could be predicted using habitat variables, and whether these putative predictor variables differ among species/genotypes. The Jefferson Salamander has been designated as Threatened in Canada, and determination of its critical habitat has been deemed an important part of its recovery plan. Radiotelemetry on 16 polyploid unisexuals was employed to determine the average post-breeding migration distance and terrestrial microhabitat use. A range of biologically significant habitat variables was measured at a variety of breeding and non-breeding pond sites and in the surrounding forest habitat. The presence or absence of the various species/genotypes was determined by collecting egg masses and tissue samples from larvae and breeding adults. Post-breeding migration distance was determined using GIS and the habitat variables were analyzed using AIC. These types of data are typically used in the description of critical habitat, but given the results of this study it seems crucial that the concept of critical habitat and the method of its determination be critically reevaluated.

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Observation of egg carrying by male nurseryfish, *Kurtus gulliveri*: Natural history notes from northern Australia

Egg carrying by male nurseryfish, *Kurtus gulliveri* (Perciformes: Kurtidae) is often cited in literature reviews of parental care, but rarely witnessed in nature. During 20 field trips in October-November 2003, and eight trips in July-August 2004, 988 nurseryfish (70% male, 30% female) were collected by gill netting in Marrakai Creek, a tributary of the Adelaide River 65 km east of Darwin, Northern Territory. Seven egg masses (six unfertilized and one containing eyed embryos) were caught during 2003 in the nets, stripped from the male supraoccipital hook by the mesh. This demonstrates that eggs become attached to the male before

fertilization. We observed males carrying eggs, and we witnessed the subsequent detachment of the egg mass. Two unfertilized and six fertilized egg masses were caught in gill nets in 2004. A table of 29 other species that were caught with *Kurtus* is provided. This includes 31 specimens of the undescribed speartooth shark, *Glyphus* sp. A. The polynemid, *Eleutheronema tetradactylum*, regurgitated a partially digested nurseryfish, and a barramundi, *Lates calcarifer*, had a nurseryfish in its stomach. These represent the first records of fish predation on *Kurtus gulliveri*. A nurseryfish specimen with a minute left pupil is illustrated for the first time—a teratological phenomenon known as a pin-hole camera eye. In July and August 2004 electrofishing in Marrakai Creek and Beatrice Creek was carried out in an attempt to collect males with intact egg masses. This technique was very effective for barramundi but not for nurseryfish as they prefer the deeper mid-channel rather than the more easily shocked bank. Water chemistry data are presented showing that this region of the Adelaide River is of low conductivity and high turbidity.

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Assessment of parentage in clutches of Alligator Snapping Turtle (*Macrochelys temminckii*) eggs using microsatellite markers

The Alligator Snapping Turtle (*Macrochelys temminckii*) is the largest freshwater turtle in North America. It has been heavily exploited in the past and now receives some protection in every state within its range. *Macrochelys* exhibits strong sexual size dimorphism, suggesting that forced insemination may occur in the wild. Multiple paternity may result from forced insemination, multiple matings, or sperm storage. Determining whether or not *Macrochelys* exhibits this mode of reproduction is important because it may help slow the loss of genetic variability through drift in small populations. The genetic benefit of this reproductive tactic to the female include increasing the possibility of sperm competition and insuring that the sperm of at least one of her mates is genetically compatible with her own gametes. Increases in offspring quality and even overall population size are the ultimate consequences of these genetic benefits. The absence of evidence of multiple paternity may indicate that female mate choice, and not forced insemination may occur in the wild. Another possibility is that females do not encounter more than one male in the breeding season and therefore do not have the opportunity to mate with multiple sires. This study uses microsatellite regions in DNA to determine the parentage of nine clutches of *Macrochelys* collected from Black Bayou Lake National Wildlife Refuge in northeast Louisiana. Microsatellites mutate at such a high rate that they are good indicators of parentage. Microsatellites have been used to observe the occurrence of multiple paternity in nearly all turtle species studied including, 37.5% of *Podocnemis expansa* clutches, 66% of *Chelydra serpentina* clutches, 33% of *Caretta caretta* clutches, and 58% of *Lepidochelys kempii* clutches. Two microsatellite loci have already been identified for *Macrochelys*, and others will be adapted for *Macrochelys* from other closely related turtle species.

BESSERT, MICHAEL L.

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Conservation genetics in the genus *Cycleptus* (Catostomidae) based on mtDNA and microsatellite data

Cycleptus is a geographically widespread genus of suckers (Catostomidae) that occurs in large rivers throughout the Mississippi, Rio Grande, and Mobile basins as well as several disjunct coastal drainages in central North America. The genus was considered monotypic for over 175 years as *Cycleptus elongatus* until the recent morphological description of a sister species, the southeastern blue sucker (*C. meridionalis*). A subsequent allozyme study suggested an additional distinct type in the Rio Grande basin of western North America. In this study, I have assessed range-wide mtDNA diversity to determine whether previous morphological and allozyme distinctions are supported by molecular genetic data and to ascertain whether each disjunct coastal drainage harbors a unique genetic type. Results show that three geographically isolated clades exhibit reciprocal monophyly at the mtDNA control region. Two conform to the current species delineations while the third occurs in the Rio Grande basin. Phylogenetic topology and genetic distance between clades indicate that populations in the Rio Grande basin may warrant description as a third species. Microsatellite and mtDNA genetic data are also being used to estimate local population parameters such as effective population size and gene flow between disjunct areas. These results have important implications for conservation given that populations in the Rio Grande basin are currently recognized as *C. elongatus* and that cycleptids are categorized as S3 (vulnerable) to S1 (critically imperiled) in all 21 states where they occur. **STOYE CONSERVATION**

***BETANCUR, RICARDO; ACERO, ARTURO; BERMINGHAM, ELDREDGE; COOKE, RICHARD**

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Systematics, evolution, and biogeography of New World Ariids as inferred from mitochondrial, nuclear and morphological evidence

Phylogenetic relationships for 37-41 New World and two Old World species of sea catfishes are hypothesized using maximum parsimony (MP) and Bayesian inference (BI) optimality-criteria on 2922 mitochondrial (cytochrome b, ATP synthase 8 and 6, ribosomal 12S and 16S) and 978 nuclear (RAG2) characters. Mitochondrial data yielded clades highly resolved at subfamilial, generic and specific levels. Nuclear RAG2 data showed poor resolution and BI responded with higher sensitivity than MP to the low phylogenetic signal. The molecular phylogeny was compared to a previously compiled morphological data set that was expanded herein to a total of 23 ariid species and 56 characters. The phylogeny derived from MP analysis of the morphological data was highly congruent with those derived from the molecular evidence. All topologies agree in the division of Ariidae into two subfamilies (ariines and the monogeneric

galeichthyines). The monophyly of the genera *Ariopsis*, *Bagre*, *Cathorops*, *Galeichthys*, *Notarius*, and *Sciades* and the validity of *Potamarius* is supported. The genus *Arius* as commonly recognized is not monophyletic and should not be applied to New World species. '*Arius*' *dasycephalus* was recovered as a primitive *Cathorops* lineage. *Potamarius* and *Ariopsis* formed a clade sister to *Sciades*. '*Arius*' *platypogon* was often recovered as an independent lineage within ariines clade and should be placed in a new genus. Phylogenetic positions of four taxa confined to freshwaters imply three independent reversions from the derived condition of ariids (i.e., marine or estuarine inhabitants) to the primitive condition of Otophysi (i.e., freshwater inhabitants). Diversification of the predominantly tropical ariines likely occurred in the Tethys Sea whereas speciation events in the subtropical galeichthyines are probably tied to the southern coast of Gondwana.

***BETHEA, D.M.; HALE-WILLIAMS, L.; CARLSON, J.K.; CORTÉS, E.; MANIRE, C.A.; GELSLEICHTER, J.**

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Latitudinal variation in the diet and daily ration of the bonnethead shark *Sphyrna tiburo* from the eastern Gulf of Mexico

Bonnethead *Sphyrna tiburo* diet and daily ration were determined for three major areas in the eastern Gulf of Mexico: northwest Florida (latitude $\approx 30^{\circ}\text{N}$), Tampa Bay ($\approx 28^{\circ}\text{N}$), and Florida Bay ($\approx 25^{\circ}\text{N}$). In each area, diet was assessed size classes (40-60, 61-80, and 81-100+ cm TL) and quantified using six indices: percent by number, percent by weight, frequency of occurrence, the index of relative importance (IRI), IRI expressed on a percent basis (%IRI), and %IRI based on prey category (%IRIPC). In northwest Florida, a mix of decapod crabs, decapod shrimps, and crustaceans other than lobster were found in stomachs of sharks 40-60 cm TL (n=78). Stomachs of sharks 61-80 cm TL (n=60) and 81-100+ cm TL (n=51) contained mostly decapod crabs. The same trend was observed in Tampa Bay for the larger two size classes of sharks (n=103 and n=61, respectively). In Florida Bay, sharks 40-60 cm TL (n=27) fed on crustaceans and cephalopods, sharks 61-80 cm TL (n=90) took fewer decapod crabs and shrimps and more lobsters and cephalopods, while the diet of sharks 81-100+ cm TL (n=38) was dominated by cephalopods, lobsters, and decapod crabs. Correlation and simple correspondence analysis showed diets from northwest Florida and Tampa Bay to be similar; diets of sharks from Florida Bay were different. A bioenergetic model was constructed to estimate daily ration using diet data from this study and species-specific inputs from other studies. Daily ration was different among areas and life stages. Daily ration was highest for young-of-the-year sharks and lowest for adult sharks.

***BEVIER, CATHERINE R.; PARKER, JILLIAN E.; CONLON, J. MICHAEL**

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Antimicrobial peptides in skin secretions from frogs of the *Rana catesbeiana* species group

A remarkable variety of compounds are synthesized and secreted in anuran amphibian skin. These serve primarily to protect the animal from predators and pathogens. Ten peptides from secretions collected from the mink frog, *Rana septentrionalis*, and carpenter frog, *R. virgatipes*, members of the monophyletic *R. catesbeiana* species group, were purified and structurally characterized, and showed differential inhibition of microorganism growth. The distribution of these peptides in these two ranids, and in other North American ranid frogs that have been analyzed, can be studied in a phylogenetic context, and contributes to a better understanding of potential pathogenic sources of recent amphibian population declines, such as the chytrid fungus, *Batrachochytrium dendrobatidis*. For example, ranalexin has only been detected in members of the *R. catesbeiana* species group, including *R. catesbeiana*, *R. gryllo*, *R. clamitans*, and *R. virgatipes*, but were not found in skin secretions from *R. septentrionalis*. On the other hand, four paralogs of brevinin-1, a family of peptides widely distributed in the skins of Eurasian ranids and North American ranids in the *R. pipiens* species group, and a highly potent brevinin-2-related peptide were isolated from secretions from *R. septentrionalis*. We are continuing investigations of interspecific and geographic variation in the peptides, and especially their effectiveness on local microbial fauna. These peptides could also contribute to the development of novel antimicrobial agents to treat the rising numbers of antibiotic-resistant pathogenic bacteria.

***BICKFORD, JOEL; LOWERRE-BARBIERI, SUSAN; WALTERS, SARAH**

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Determining the number of ultrasonic receivers needed to evaluate fish residence times.

Sonic tags and remote receivers can be used to determine the movement of fishes. In order to use remote receivers to determine residence times, tag range has to be determined. We tested the ranges of two Vemco VR2 receivers and Vemco V8sc-2L tags in Tampa Bay at Bunces Pass in March 2004. A single spotted seatrout, *Cynoscion nebulosus*, was captured and internally implanted with a sonic tag and held for an extended period in a netpen that was anchored on the bottom. One receiver was placed at a distance of 85m and the other at 170m from the netpen and both were moored approximately 1.5m off the bottom. A macro was written in Microsoft Excel to give quantitative measurements of reception. Tag reception of the 170m receiver was significantly lower than that of the 85m receiver over the test period. With respect to current, the 170m VR2 reception varied significantly between the ebb and flood tides, whereas the 85m VR2 did not. Based on the minimum range at which there was consistent

reception, Arc View 3.3 was used to determine the GPS positioning of an array of 18 VR2 receivers. This array ensures that if a tagged fish occurs anywhere within our predetermined sampling area, it will be detected under all tidal regimes.

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Reproductive biology and fishery aspects of the golden cownose ray, *Rhinoptera steindachneri* (Evermann and Jenkins, 1891) from the Gulf of California and Pacific coast of Baja California Sur, Mexico

The golden cownose ray, *Rhinoptera steindachneri* (Evermann and Jenkins, 1891), is widespread in coastal waters of the tropical and subtropical eastern Pacific. It was among the most abundant species taken in artisanal elasmobranch fisheries of the Gulf of California and Bahía Almejas (Baja California Sur), Mexico, during 1998-2000. In the northern Gulf of California, *R. steindachneri* landings peaked during summer months and were negligible during winter. In Bahía Almejas, this species was frequently landed in August and uncommon in June, a trend also noted in CPUE (#individuals/vessel/trip; August =1.13, June=0.13). Size segregation and schooling behavior was evident from landings in both regions. Disc width (DW) of *R. steindachneri* harvested in the Gulf of California ranged from 39-98 cm and averaged 64.2 cm for males (n=585) and 64.4 cm for females (n=505). The largest male (96 cm DW) and female (104 cm DW) were recorded at Bahía Almejas. Size at first maturity and 50% median maturity were similar for males (64 cm, 69.9 cm DW) and females (65 cm, 70.0 cm DW). The largest immature male was 78 cm DW and the largest immature female was 72 cm DW. Fecundity was determined to be one offspring per female with larger females carrying larger embryos. Parturition was estimated to occur from late June to August at 39-45 cm DW after a gestation period of 10-12 months. Bahía Almejas served as a nursery ground for neonate *R. steindachneri* and a likely breeding location for adults. The conservative reproductive strategy of *R. steindachneri*, in which a single pup is produced annually after maturity is reached at a relatively large size, suggests that this species is of low productivity and highly susceptible to overexploitation.

BJORGO, KIMBERLY A.

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Interactions between selected large river fish species and their habitat

Ecologists are beginning to gain a deeper understanding of the effects of human perturbations on the fish community within large rivers. While many studies in large rivers have begun to uncover the factors determining fish abundance and distribution. The importance of channel margins, backwaters, and island habitats

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are relatively well-understood. Preliminary research fails to include the role of the main channel or thalweg area in large river fish distributional ecology. We used radio telemetry to examine habitat interactions between and among large river fish species in the Marmet Pool of the Kanawha River, West Virginia USA. The 105 fish used in this study were captured via a combination of boat-mounted electrofishing and gill nets. There were a total of 1096 observations made during the three years research. Freshwater drum (n=22) were detected 243 times. Common carp (n=30) were detected 341 times. Smallmouth buffalo (n=33) were identified 364 times. Hybrid striped bass (n=10) were detected 71 times. Flathead catfish (n=6) were detected 36 times. Channel catfish (n=4) were detected 41 times. The percent contribution of each genus to the total number of observations varied, but 66% of all observations were made on common carp and smallmouth buffalo. Both geographic information systems (GIS) analysis and conventional statistical analysis were used to compare habitat use and availability. Analysis indicated that habitat use was differed between species. Interestingly, thalweg areas seemed to be an important habitat choice based on the high correlation of main channel habitat use and availability. The interaction between species showed a surprising degree of similar habitat choices. **STOYE GENERAL ICHTHYOLOGY**

BLACKBURN, DAVID C.

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Osteology of *Arthroleptis* and *Schoutedenella* (Anura: Ranoidea: Arthroleptidae)

Few studies have addressed osteological diversity within African ranoid frogs. Exceptions include studies of the Hyperoliidae (Laurent 1941b, 1944; Drewes 1984; Wilson 2000), Ranidae (Clarke 1981) and taxa currently treated as the Petropedetidae (Laurent 1941a). In addition, Raymond Laurent (1940, 1941a,b) discussed the osteology of a diverse range of ranoids including taxa currently included in the Arthroleptidae, Astylosternidae, Hyperoliidae, Petropedetidae, and Ranidae (Frost 2004). Laurent (1973) proposed a specific phylogenetic hypothesis for the relationships within the Arthroleptidae based on a suite of skeletal morphologies. In the light of more recent work on the effects of small body size on skeletal morphology in amphibians (e.g., Hanken 1983, 1984; Hanken & Wake 1993; Wake 1986), it is apparent that many of the characters proposed to unite the genus *Schoutedenella* may be due to the evolution of small body size and thus not necessarily indicative of close phylogenetic relationship. My research addresses the effect of body size and growth on skeletal morphology within the Arthroleptidae and aims to resolve whether small body size, and thus similar skeletal morphologies, have evolved convergently within this group. Thus far, my research on osteology within the Arthroleptidae, particularly in *Arthroleptis* and *Schoutedenella*, indicates potentially greater osteological diversity than was recognized by Laurent. Two particularly interesting results include the ability to easily discriminate between species that are essentially cryptic based on external morphology (e.g., *Schoutedenella xenodactylus* and *S. xenodactyloides*) and that the osteology of species currently placed in the genus *Schoutedenella*, characterized by small body size, exhibits marked heterogeneity. In addition, comments will be made on postembryonic skeletogenesis in *Arthroleptis* and *Schoutedenella*. **STORER HERPETOLOGY**

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The geographic distribution of genetic diversity in the *Etheostoma flabellare* species complex (Percidae, *Catonotus*) from the lower Atlantic Slope River drainages of North and South Carolina

Based on morphology, the fantail darter, *Etheostoma flabellare*, is highly variable geographically and has long been recognized as a species complex. To assess the magnitude of variation and unrecognized diversity in the *E. flabellare* species complex, I examined genetic variation among populations from across the geographic range of the complex using two molecular markers, the mitochondrial ND2 gene and intron 1 of the nuclear S7 gene. Phylogenetic analyses generated congruent trees for both S7 and ND2 data sets and recovered several distinct lineages, which have each undergone subsequent diversification. One of these lineages, a well-supported, monophyletic clade containing *E. flabellare* from the Pee Dee, Santee, Savannah and Cape Fear River drainages, and the New (Ohio R.) and upper Tennessee river systems, was further examined for population-level genetic structuring. The ND2 gene was sequenced for an additional 70 individuals from 30 localities within this clade to investigate the geographic distribution of genetic diversity and the level of population subdivision. Examination of ND2 haplotype networks generated for these individuals revealed high levels of population subdivision across drainage divides and at smaller spatial scales within river systems. Sampled haplotypes were not shared among populations from different drainages or among sub-populations within drainages. The genetic structuring of populations in the lower Atlantic Slope region is generally congruent with the observed geographic variation in morphology. However, many genetically distinct populations share similar morphologies, suggesting that populations are more subdivided than predicted by morphology alone. **STOYE GENERAL ICHTHYOLOGY**

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Body size and head size of island *Boa constrictor* in Belize: Environmental and genetic contributions

Marked differences in body size and head size have been documented between island and mainland populations of boas (*Boa constrictor*) in Belize. Island boas average one-half the length and one-fifth the mass of mainland boas and island boas have longer heads and larger eyes compared to mainland boas. However, the genetic and environmental contributions to these differences are unknown. Herein, we describe patterns of offspring size and reproductive investment in island and mainland boas and present the results of two common-garden experiments; the first designed to elucidate genetic and environmental contributions to body size and the second designed to elucidate the effects of

prey size on head size. The results demonstrate that island and mainland boas contribute similar proportions of their mass to litters but that island boas have smaller litters of smaller neonates compared to mainland boas. After rearing in the common-garden, island boas made up a difference in mass (in 50 days) and length (in 100 days) but then achieved growth rates that were less than that of mainland boas and ultimately island boas did not achieve a smaller size compared to mainland boas. However, in the lab island boas grew larger than most wild-caught snakes. Our results support the idea that body size differences between island and mainland boas are due to a mixture of genetic modification of growth rates and phenotypic plasticity. Results from the head size experiment showed that after adjusting for body size, island boas were born with cranial elements of different size compared to mainland boas. When reared on a diet of either one large or 2 small rodents, we found no effect of prey size or location (island versus mainland) suggesting that boa cranial elements are genetically fixed and differences in head size of free-ranging boas may be locally adapted.

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Mitochondrial genetic variation of the Mahi Mahi *Coryphaena hippurus* from the central and eastern Pacific

Pelagic species such as the circumtropical mahi mahi *Coryphaena hippurus* face few barriers to dispersal. In Mexico, this species is reserved to recreational fisheries and commercial exploitation is not permitted by law. The need to revise this management policy has prompted the issue of whether Mexican mahi mahi can be managed as a single stock or more. Here we present genetic data from specimens collected in Hawaii and the eastern Mexican Pacific, to provide some insight to the possible existence of genetically differentiated subpopulations in this region of the species range. PCR-RFLPs of the mitochondrial NADH1 gene revealed relatively high levels of haplotypic diversity and moderate levels of nucleotide diversity. Statistical analyses of genetic heterogeneity showed no evidence of genetic structure in the populations sampled suggesting that high levels of gene flow prevail in this region. Nevertheless, these results are preliminary in that they are constrained both geographically and genetically, future analyses of a larger data set including more localities and loci will provide more definitive answers on the levels of genetic differentiation of mahi mahi in the eastern Mexican Pacific.

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The *Conorhynchos conundrum*: Investigating the phylogenetic position of an enigmatic neotropical catfish (Siluriformes, incertae sedis)

Conorhynchos conirostris, the only valid species in the genus *Conorhynchos*, is thought to be endemic to the Rio São Francisco. For a long time, the taxon has been included in the large neotropical family Pimelodidae. However, that placement of *Conorhynchos* was based exclusively on the general aspect of the fish, since scarcity of study material discouraged detail investigation of its anatomy. Recent study based on new material reveals that *Conorhynchos* does not share the known synapomorphies for Pimelodidae or any of its major subgroups. In fact, *Conorhynchos* does not share known synapomorphies with any single current catfish family, neotropical or otherwise. In this study, we review all the morphological evidence for putative placements of *Conorhynchos*, with a comparative coverage encompassing practically all siluriform families. We survey with special emphasis the possible relationships of *Conorhynchos* with Pimelodidae, Bagridae, Auchenoglanididae, Doradoidei (Doradidae, Auchenipteridae and Mochokidae) and "arioids" (Ariidae, Claroteidae, Pangasiidae, Schilbidae). The morphological evidence points most strongly to the hypothesis that *Conorhynchos* is a member of the suborder Doradoidei (Mochokidae + Auchenipteridae + Doradidae). Further characters indicate that the genus is sister group either to Doradidae plus Auchenipteridae or to all other doradoids. Either phylogenetic position requires recognition of a separate family for *Conorhynchos*, and implies respectively a relatively simple or a complex biogeographical explanation. We look forward to testing these hypotheses with additional broadly comparative data. This research is supported by CNPq, FAPESP, and NSF.

***BOGART, JAMES P.; BI, KE**

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Identification of genomes in multigenomic unisexual salamanders (genus *Ambystoma*) using GISH

More than 20 nuclear genomic combinations are known to exist in natural populations of Eastern North American unisexual salamanders in the genus *Ambystoma*. These females are mostly triploid but diploid, tetraploid, and pentaploid individuals have also been found in the complex. Based on isozymes, individual unisexual females have chromosomes that are derived from two, three or four distinct, normally bisexual species (*A. jeffersonianum* (JJ), *A. laterale* (LL), *A. texanum* (TT), *A. tigrinum* (TiTi)). Based on mitochondrial genes, the originating female for the unisexual complex is a fifth species (*A. barbouri*). The unisexuals live in sympatric association with at least one of the four bisexual

species. Sperm from a sympatric male is required for development of the unisexual eggs but is usually not incorporated and the eggs can develop by gynogenesis. Occasionally, the genome of a male is incorporated to elevate the ploidy level or to replace a genome. Unisexuales are automictic. Meiosis involves a pre-meiotic doubling of the chromosomes followed by a reductional division. All of the four bisexual species that can contribute chromosomes to the unisexuales have very similar karyotypes and, using conventional cytogenetic techniques, the chromosomes can only be counted to confirm ploidy level. We applied genomic *in situ* hybridization (GISH) techniques to document the genomic contribution of *A. laterale* and *A. jeffersonianum* in LJJ and LJJJ unisexuales. Previous hypotheses of genetic stability and monophyletic unisexual clonal lineages are not supported. Observed inter- and intra-genomic chromosomal translocations demonstrate that unisexuales undergo considerable genetic restructuring. Genetic variation and genomic interaction within unisexual individuals explain both their evolutionary success in mixed unisexual-bisexual populations well as the high frequency of embryonic mortality that is observed in all unisexual populations.

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Evolution of post-zygotic isolation in Centrarchidae

It is well known that the more distantly related two species are, the less likely they are to hybridize. However, many questions remain about the speed at which reproductive isolation evolves, its genetic basis, and the role of divergent natural selection. We conducted a comparative analysis of hybridization success in centrarchids, to quantify the relationship between hybrid viability and the amount of time two species have been evolving in isolation. We took advantage of a well-resolved phylogeny of Centrarchidae based on 7 genes, and fossil calibrations from within the clade, to generate estimates of divergence time between all possible species pairs. We then collected published data on hybrid viability in centrarchids. Using a statistical correction for the phylogenetic non-independence between different pairs of species, we showed that hybrid viability declines at a constant rate after a lag time of about 6 million years during which hybrid viability remains equivalent to or even exceeds the viability of pure species controls. After this lag, viability is lost at a rate of 3% of hybrid embryos per million years of divergence. This is the slowest rate yet documented for the evolution of post-zygotic isolation. We argue that the absence of distinct sex chromosomes in centrarchids eliminates the capacity for this family to experience Haldanes Rule, and therefore centrarchids evolve genetic incompatibilities more slowly than in other vertebrate groups, suggesting that chromosomal architecture influences the rate of speciation. Evidence for cyto-nuclear incompatibilities is based on the observation that reciprocal crosses between species yield asymmetrically viable F1 hybrids, which requires interactions between haploid and diploid loci. Finally, we present evidence that body size divergence, indicative of ecological divergence, can promote speciation. This is based on our finding that species pairs with greater body size divergence have lower hybrid viability than expected given their divergence time.

BOMMARITO, BIANKA

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Choice of spawning temperature by Neotropical cichlid fishes

Fishes are very particular about choosing when and where to spawn. Many factors may affect a parent's choice of where to spawn such as substrate availability and temperature of the water. Water temperature is very important because it likely affects oxygen concentration and developmental rates of the offspring. Warm water holds less oxygen than cool water, and larger eggs consume more oxygen than smaller eggs. We predicted that when given a choice, parents should choose a temperature based on the size of eggs that they will lay, i.e., fish that lay larger eggs should prefer to spawn in cooler water than fish that lay smaller eggs. To test this, we designed and built a temperature-based spawning-choice apparatus. The apparatus enables a pair of fish to have four different temperatures to choose from in which to spawn. Working with neotropical cichlids (e.g., *Archocentrus nigrofasciatus* and *Archocentrus spinosissimus*), we found that individuals of a species make precise and consistent choices of the temperature at which to spawn. **STOYE ECOLOGY & ETHOLOGY**

***BONETT, RONALD M.; MOLER, PAUL; VAN DEVENDER, R. WAYNE; VIEITES DAVID R.; CHIPPINDALE, PAUL C.**

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Biogeography and evolution of body size and toe number in the salamanders of the family Amphiumidae

The enigmatic salamanders of the family Amphiumidae inhabit lowland aquatic ecosystems throughout the Coastal Plain of the southeastern United States. The only extant genus, *Amphiuma*, includes three elongate, permanently aquatic species with four highly reduced limbs that append one, two, or three toes. The large-bodied species *Amphiuma means* and *A. tridactylum* are more widespread, occurring across the Atlantic and the Mississippi Coastal Plains, respectively, whereas the diminutive *A. pholeter* has a relatively limited distribution across the panhandle of Florida and adjacent states. To date, the only molecular phylogenetic hypothesis for these species found *A. means* and *A. tridactylum* to be very close relatives (Nei's D = 0.12), and very divergent from *A. pholeter* (Nei's D \geq 0.73). However, even though this study was based on 24 allozyme loci, it only analyzed a very limited number of populations. Here we present the first phylogenetic analysis of the Amphiumidae based on DNA sequences. We sequenced \approx 1350 bp of mt-DNA (cyt b and 16S) for many individuals from throughout the distribution of the three species. We found at least three very divergent mt-lineages in this family. These lineages roughly correspond to the three currently recognized taxa but, contrary to the former allozyme study, we found a group of *Amphiuma* with three toes to be most divergent. This

discrepancy in our results appears to be due to discordance among allozymes, mt-DNA, and toe number across the species boundary between *A. means* and *A. tridactylum*. To further address this trichotomy we sequenced approximately half of the mt-genome (~8000 bp) and the nuclear gene Rag-1 (~1500 bp) for representative individuals. Using this new robust phylogeny for the family, we clarify species boundaries and taxonomic issues, and present hypotheses for biogeography, evolution of body size, and digit reduction in the Amphiumidae.

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Growth in spotted seatrout (Sciaenidae) as an indicator of estuarine conditions in the southeastern U.S.

The life history features of the spotted seatrout, *Cynoscion nebulosus*, have tremendous potential in being able to discern long-term trends in conditions within and among estuaries because the species is widely distributed (i.e., coastal areas from North Carolina to Mexico), is both commercially and recreationally important, and rarely leaves its home estuary. Thus the estuarine conditions to which it was subjected while growing could be reflected in changes in its life history features such as growth. About 400 spotted seatrout were collected from April to August 2003 from the lower Caloosahatchee River/Estuary in southwest Florida (USA). Otolith sections were examined with enhanced imagery to facilitate recording age and annulus increments from the otolith. Males and females were from 1-4 years of age and displayed a significant relationship between otolith radius and fish length that was different between sexes. A comparison of back-calculated size at Age 1 for four separate year classes (1999-2002) indicated that there were significant differences in growth among year classes. Time-series analysis indicated one-year lags in seagrass density and salinity were associated with fish growth. These environmental conditions are artificially manipulated in this estuary and may be responsible for the differences in growth rates observed for both males and females among year classes. Ongoing research will determine year-class specific growth parameters for other estuaries in the southeastern U.S. to allow comparisons between years and among estuaries.

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Molecular characterization of major histocompatibility complex class II alleles in wild tiger salamanders (*Ambystoma tigrinum*)

Major histocompatibility complex (MHC) class II genes are usually among the most polymorphic in vertebrate genomes because of their critical role (antigen presentation) in immune response. Prior to this study, class II genes were poorly characterized in tiger salamanders (*Ambystoma tigrinum*), but the axolotl (*A. mexicanum*) class II gene is thought to lack allelic polymorphism. The monomorphism of the axolotl class II gene could be due to relaxed selection,

phylogenetic constraints, or demographic history. Here, we use a comparative approach with tiger salamanders to differentiate among these alternate hypotheses. In this study of the evolution of MHC genes in urodele amphibians, we describe for the first time a polymorphic class II gene in wild tiger salamanders. We sequenced the peptide binding region of a class II gene from wild *A. tigrinum* (n = 33) and identified 9 distinct alleles. Observed heterozygosity was 73% and there were a total of 46 polymorphic sites, most of which correspond to amino acid positions that bind antigens. Patterns of nucleotide substitutions exhibit the signature of diversifying selection, but no recombination was detected. We have no direct data on the immunoefficiency of tiger salamanders, but the levels of polymorphism in our study population should suffice to bind a wide variety of foreign antigens (unlike axolotls). Our tiger salamander data suggest that the monomorphism associated with axolotl class II genes is a relict of their unique historical demography, not their phylogenetic legacy.

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Identification of steroid hormones in the allantoic fluid and plasma of loggerhead hatchlings

Assessing sex ratios for populations of sea turtles is an important aspect of species conservation. Laboratory studies of temperature and sex ratios have provided the community with good estimates of sea turtle pivotal temperatures, but may not be predictive in natural environments where temperatures are consistently changing. This project has developed a novel procedure for detecting the estrogens and testosterone in allantoic fluid and blood plasma of hatchling loggerhead sea turtles. Collection of egg fluids is non-invasive to the turtles, while blood collection is relatively easy for conservationists and scientists. Eggs were incubated in individual cups approximately 1 week prior to the estimated hatch date. Upon hatching, 2 mls of allantoic fluid were collected, and 200 μ l of blood was collected from the 2-3 day old hatchlings. These samples were frozen, extracted twice with ethyl acetate, dried under nitrogen and finally resuspended in an acetonitrile and distilled water mixture. High performance liquid chromatography was performed in the laboratory to determine hormone profiles. These profiles were compared to known standards to determine concentrations within the initial sample and percent recovery. Steroid hormones are readily detectable in both the allantoic fluid and plasma, with estrone concentrations highest in the egg fluids. Estrone and estradiol levels are both high in the plasma. Fluid estradiol levels were below equipment detection limits, but this hormone was detectable in plasma. This method could provide a means to assess sea turtle sex ratios in large populations at different ages and life stages.

***BOWEN, BRIAN W.; ROCHA, LUIZ A.; MUSS, ANDREW; GRANT, W. STEWART**

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Shallow mtDNA coalescence in Atlantic pygmy angelfishes (genus *Centropyge*) indicates a recent invasion from the Indian Ocean

Pygmy angelfishes (genus *Centropyge*) are widespread and species-rich in the Indo-Pacific, but only three species (distinguished by color patterns) are recognized in the Atlantic: *C. resplendens* on the mid-Atlantic ridge, *C. argi* in the Caribbean, and *C. aurantonotus* in Brazil and the southern Caribbean. Atlantic species are very similar to *C. acanthops* in the western Indian Ocean, raising the possibility that pygmy angelfish recently invaded the Atlantic Ocean via southern Africa. To test this zoogeographic hypothesis, we compared a 454 bp segment of the mtDNA control region among pygmy angelfishes of the subgenus *Xiphypops*, which includes the three Atlantic species, the Indian Ocean species, and a Hawaiian endemic (*C. fisheri*). The Indian Ocean *C. acanthops* is closest to the Atlantic species ($d = 0.059$) relative to the Hawaiian *C. fisheri* ($d = 0.077$). The mtDNA genealogy indicates a dispersal pathway from the Indian Ocean to the West Atlantic, rather than to the Gulf of Guinea or the mid-Atlantic ridge. Mismatch and coalescence analyses indicate Atlantic colonization by a few tens of individuals, about 250,000-500,000 years ago. The three Atlantic species are polyphyletic, raising doubts about taxonomic assignments based primarily on color pattern.

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Evaluation of juvenile Brown Treesnake (*Boiga irregularis*) trappability in response to abundance of an introduced skink (*Carlia ailanpalai*)

Operational snake trapping is an effective tool for capturing medium to large (>900 mm SVL) Brown Treesnakes (*Boiga irregularis*, BTS) on Guam, although it seems to be relatively ineffective for small snakes (<800 mm SVL). Current trapping methods, using live domestic mice for bait, may not be attractive to small BTS, which forage primarily for lizards. This is problematic because small snakes constitute about half of the snakes on Guam and comprise the majority of snakes removed from outbound cargo. Small BTS also cause most of the snake-induced power outages on Guam. In 2003 small snake trappability was estimated with reference to trap attractant and abundance of a common introduced skink (*Carlia ailanpalai*) at two sites on northern Guam. Body condition was the most important predictor of capture probability, with BTS of poorer body condition being more trappable. As expected, traps tended to capture few small BTS. There was slight evidence of increased trappability on the site with low skink

abundance. A strong bait x site interaction was observed, with more BTS caught in mouse-baited traps at one site. Trap-capture rate indicated a strong decrease in snake activity shortly after dawn and activity did not increase again until early evening. In 2004, no difference in small BTS trappability was observed during a prey manipulation experiment conducted in two outdoor 20 m x 20 m enclosures. As in 2003, snakes ceased entering traps shortly after dawn. Improvements to trap design, attractants targeting small snakes, and further research into small BTS foraging strategies and movement are recommended.

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Reproductive parameters for population assessment of *Squalus megalops*

Population assessments of chondrichthyan species require several key parameters of their reproductive biology, which were estimated for *Squalus megalops*. For both sexes, length-at-maturity differed depending on the criterion adopted for defining maturity. For males, length-at-maturity is smallest when condition of seminal vesicles is adopted as a maturity criterion. For females, length-at-maturity is smallest when the largest follicle diameter >3 mm is adopted as the criterion for maturity; this is appropriate only as an indicator of the onset of maturity. Mature males are capable of mating throughout the year. Females have a continuous asynchronous reproductive cycle. The sex ratio of embryos is 1:1 and litter size and near-term embryo length increase with maternal length. Females have an ovarian cycle and gestation period of two years. This is reflected in the differences found between the maturity and maternity ogives. Although all females are mature at 600 mm, only 50% of them contribute to annual recruitment each year. Hence, for chondrichthyan species with reproductive cycles of two, three or more years, if maturity ogives are used in population assessments instead of maternity ogives, the models would over-estimate recruitment rates. **AES GRUBER**

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School and shoal distributions in a freshwater catfish species, *Corydoras paleatus* (Callichthyidae)

The South American armored catfish *Corydoras paleatus* has been observed to occur in nature in large schools, in smaller shoals, and individually or in pairs. These catfishes are advantageous for laboratory study because they are easily bred and raised, they spend large amounts of time resting between bouts of swimming and foraging, and their resting behavior in particular is easily quantified. In these experiments, we explore (1) how individuals allocate their time among foraging/shoaling, schooling, aeration, and resting; (2) how much time individuals spend in available aggregations; (3) distributions of nearest-

neighbor distance; (4) numbers of groups as a function of density; (5) activity patterns; and (6) how these factors change with density. We examine the implications of this research.

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Rattlesnake exclusion fences: Do they really work?

The conflict between humans and timber rattlesnakes (*Crotalus horridus*) has increased as residential and commercial developments have extended into more remote areas. The construction of exclusion fences has been proposed as a solution to minimize human/rattlesnake interactions. We report on a three-year study in New York that illuminates many of the problems with this approach. Based on the recommendations of an extensive three-year pilot study, an exclusion fence was completed in 2000. The fence was positioned to minimize the possibility that rattlesnakes would move down slope into the subdivision area after emerging from their den. The 1.2 m high fence, constructed with 1.3 cm hardware cloth buried in the ground and supported by metal rods, extended along the slope for approximately 2400 m. Between 2001-2003, six timber rattlesnakes were tracked using implanted radio transmitters. In spite of the fence blocking direct access, by the end of 2002 all six rattlesnakes had entered the subdivision. Five of the radio-tagged snakes returned to the subdivision in 2003. Each was relocated to a pre-selected area up slope from the fence. Sixteen translocations were performed on five snakes, four of which returned to the subdivision on one or more occasions. Although difficult to confirm, based on movement patterns, snakes appeared to move through the fence on many occasions, as well as around both ends of the fence. Breaches in the integrity of the fence appeared to be a function of inadequate design, poor installation and lack of sufficient maintenance. In addition, fourteen other rattlesnakes were also found within the subdivision and two rattlesnakes were found dead in the subdivision area during this study, possibly killed by humans. We conclude that the fence did not achieve the objective of minimizing human/snake conflicts and that exclusion fences have limited value for rattlesnake conservation.

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Differences in infection by *Batrachochytrium dendrobatidis* among sites, elevation, and habitats in central Panama

Central Panama is currently an active area of *Batrachochytrium dendrobatidis* (Bd) induced amphibian declines, where a front of new declines are consistently progressing westward. We conducted the first intensive field sampling of amphibian communities for Bd presence at two environmentally and faunally similar sites, Santa Fe (SF) and El Cope (EC), separated by 40km. We sampled stream, pool/puddle, and terrestrial habitats at high and low elevations along

two parallel elevational transects. Historically, SF and EC both showed high species richness (49, 63), abundance, and species overlap (60%). Prior to 2002-2003, Bd was not detected at SF in limited collections (0.0, CI 0.0-0.049, n=74), and first appeared in animals collected between July-August 2003 (0.464, CI 0.475-0.661, n=28). In May-July 2004, Bd prevalence was high at SF (0.30, CI 0.24-0.37, n=201), but still not detected at EC (0.0, CI 0.0-0.006, n=610) suggesting the front of infection was then between SF and EC. Logistic regression of site, elevation, and aquatic index by infection indicate the highest probability of infection occurs in species at SF occupying high elevation aquatic habitats ($\chi^2=54.91$, d.f.=1, $p<0.0001$). Post-decline prevalence at SF was high (>10%) in all habitats and species, and at high and low elevations, but only pool/puddle habitats showed corresponding high frog abundance. All persisting species are potential carriers of infection, but the remaining species occupying pool/puddle habitats at SF have broad elevational ranges, high dispersal capability, and low mortality due to infection and can thus be considered pathogen reservoirs. These reservoirs enable Bd persistence at SF, therefore, greatly limiting recovery potential. Our data support: widespread Bd infection as the mechanism of decline at SF, infection in the field is non-random, and that the post-decline community consists of reservoir species with high prevalence and abundance in pool/puddle habitats, thus potentially promoting continued infection and persistent declines.

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Patterns of decline in a tropical montane tadpole community

Adult amphibian populations have declined around the globe, although descriptions of larval population declines are lacking. We quantified changes in species composition and community structure of larval populations in four streams in a tropical montane watershed in central Panama for a year prior to declines, and for a year during and following adult mortality and population declines. We surveyed populations of seven species of tadpoles in which the adults were monitored concurrently by sampling specific habitats used by selected species (i.e., riffles for hylids; leaf packs in deep pools for centrolenids; and shallow isolated pools for *Colostethus spp*). For best results, different sampling techniques were used in each of these habitats. Prior to adult population declines, tadpoles were abundant during both dry (17.42 tadpoles/m² \pm 15.63) and wet seasons (4.13 m² \pm 5.62). Following the decline of adult populations, larval densities were reduced from previous wet (1.49 m² \pm 1.33) and dry season levels (1.78 m² \pm 1.78), with significantly fewer individuals than the previous year ($t=3.87$, 6 d.f., $p=0.008$). This decline affected all species ($\chi^2=83.37$, 6 d.f., $p<0.001$), transects ($\chi^2=82.64$, 3 d.f., $p<0.001$) and habitats ($\chi^2=13.28$, 2 d.f., $p<0.001$) and occurred \approx 1 mo. prior to finding the first dead frog. As adults continued to die, larval abundance continued to decline into the dry season of 2005 when larval abundance was significantly reduced from 5.88 m² \pm 5.98 to 0.96 m² \pm 1.34 ($\chi^2=93.82$, 6 d.f., $p<0.001$). As of March of 2005, 4 of the 7 species are missing. The 50% reduction in clutches between May-July 2003 and the same period in 2004 likely resulted from fewer breeding adults, as we found no dead or dying tadpoles. Tadpoles are important grazers in these tropical mountain streams and their loss is expected to affect predator and prey populations.

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Atlantic shark species-specific management: Is it possible?

In 2002, the stock assessment for Atlantic large coastal sharks determined that the two primary species in the fishery, sandbar and blacktips, were rebuilding and rebuilt, respectively, and that the complex as a whole was still overfished. In the 2003 Amendment 1 to the Atlantic Tunas, Swordfish, and Shark Fishery Management Plan, the National Marine Fisheries Service (NMFS) established quotas for the large coastal shark complex as a whole rather than for the individual species. This decision was made in part due to the inability of some fishermen and dealers to identify sharks correctly and in part due to the paucity of data regarding the ability of fishermen to target one or two species while avoiding other species. NMFS is currently analyzing alternatives to improve the ability of fishermen to identify sharks. However, little or no research is being done regarding the ability of fishermen to target specific sharks. Gear research in the Atlantic pelagic longline fishery has indicated that sea turtle takes can be significantly reduced by modifying hook types and using certain types of bait. Similar research is needed in the commercial shark fishery, primarily for bottom longline and gillnet gears, to determine if the bycatch of unwanted sharks, finfish, and sea turtles can be avoided or reduced. Such research could protect the more vulnerable species while still allowing for a sustainable fishery on other species and could allow quotas to be established on a more species-specific basis.

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Behavior, census and distribution of freshwater turtles in Golden Gate Park lakes

We studied the activity, distribution, population size and inter-species behavior of freshwater turtle species in Golden Gate Park lakes beginning in October 2004. The study specifically surveyed the western pond turtle *Clemmys marmorata* (a California Special Concern species) that is declining throughout its range. We used capture, mark (notching and supercool branding techniques) and release methods to estimate population sizes in each lake. Preliminary data indicated that former pets, including *Trachemys scripta* and *Trionyx* exotic species, introduced to lakes by humans have negatively affected the fitness of *C. marmorata* and the native species must compete for feeding and basking sites.

STOYE PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY

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Molecular phylogeny of cyprinid fishes in the genus *Cyprinella* from southwestern North America

The arid southwest of North America has a remarkably diverse fish fauna with the Cyprinidae being particularly important both in terms of diversity and abundance. At least nine species in the genus *Cyprinella* are restricted to the Southwest, and another, *C. lutrensis*, is broadly distributed in central North America as well as the Southwest. The southwestern fish fauna is fairly well studied in terms of species diversity, however, phylogenetic relationships for many groups remain poorly understood. We conducted a molecular phylogenetic analysis of southwestern *Cyprinella* using complete coding sequences of the mitochondrial Cyt-b, ND2, and ND4L genes. We used maximum parsimony and maximum likelihood to generate phylogenetic hypotheses for the 2485 base data set. Results suggest three major lineages of southwestern *Cyprinella*: a) an older, distinct group containing *C. proserpina* and *C. rutila*; b) a group containing *C. lutrensis*, *C. garmani*, *C. panarcys*, and *C. xanthicara*; and c) a group containing different lineages of *C. lutrensis* as well as *C. lepida*, *C. formosa*, and *C. bocagrande*. The southwestern species were not monophyletic as the proserpina-rutila clade was placed as the sister-group to *C. camura* and *C. galactura* which are native to the Mississippi basin. The remaining southwestern *Cyprinella* did form a monophyletic group, however, the presence of *C. lutrensis* in both of the major clades suggests that this widespread species may have given rise independently to several of the other species.

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Population genetic structure of the Eurasian round goby invasion in the Great Lakes

Eurasian round gobies (*Neogobius melanostomus*, family Gobiidae) are aggressive invaders in the Laurentian Great Lakes system, where they appeared in 1990. They spread rapidly throughout the lakes, but more slowly in river systems. Their invasive success may be linked to the sympatric presence of introduced dreissenid mussels, a native freshwater prey. Also in 1990, round gobies invaded the Gulf of Gdansk, Poland, located in the eastern Baltic Sea. Using two mitochondrial DNA regions, cytochrome b and the control region, we examined the population structure of North American and Eurasian round gobies from across their invasive and native ranges. We found evidence that the gobies likely arrived in North America in several, independent invasions that totaled a large fraction of the native Eurasian genetic diversity. In addition, the invasive populations show significant genetic differences between lakes. In contrast, the invasion in Poland was much smaller and contained less genetic diversity. We discerned genotypes from native, saline populations present in the freshwater Great Lakes, suggesting a potential pre-adaptation to Atlantic coastal salt

marshes. In those areas, they will find a ready food source, *Mytilus* mussels, a saltwater prey item in their native range. With their high genetic diversity and potential pre-adaptations, it is likely that round gobies will further extend their North American range, and continue a steady spread.

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Reproduction, age and growth of sheepshead, *Archosargus probatocephalus*, in Mississippi waters

Sheepshead, *Archosargus probatocephalus*, commonly occur in estuarine and offshore waters of Mississippi and are regularly targeted by fishermen. Sheepshead (N=150) were collected monthly using hook and line from December 2003 to November 2004 in Mississippi waters to assess their reproduction, age and growth. Sheepshead ranged from 110-386 mm SL (52-2,253 g) and 0 to 6 years, with age 4 fish most common in our samples. There was a highly variable but significantly positive distribution of lengths at age ($p=0.01$, $r^2=0.57$). Males are longer at a given age than females, and the von Bertalanffy growth equation (based on size and age of fish sampled) predicts a larger maximum size for male sheepshead. All females <232 mm SL were immature, although 22% of age 1 females were sexually mature. The smallest males examined histologically (222 mm SL, age 1) had spermatozoa in the testis. Ovarian maturation began in December, and GSI values of females increased in February, peaked in March and returned to low levels by May. Females are capable of multiple, but not daily, spawns, and most females captured during March and April were undergoing final oocyte maturation. Mean batch fecundity estimates are $219,100 \pm 36,700$ eggs/female (N=7), and there was no significant relationship between batch fecundity and SL or weight ($p>0.05$). Our preliminary data suggest the Mississippi sheepshead population appears to be younger, more fecund, and reaches sexual maturity sooner than sheepshead sampled during 1987-1988 in Louisiana.

BRUCE, RICHARD C.

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Did desmognathine salamanders reinvent the larval stage?

Recent phylogenetic studies of plethodontid salamanders using molecular data suggest (1) that desmognathine salamanders are nested within a clade comprising several direct-developing lineages, (2) that recognition of a subfamily Desmognathinae is no longer valid, and (3) that the biphasic species of the genus *Desmognathus* are derived from direct-developing ancestors. I examine the last hypothesis from the following perspectives: (1) the plethodontid sister family question, (2) morphology and morphogenesis, (3) the biology of the extant direct-developing species of desmognathines, (4) the ecological scenario, and (5)

problems in evolutionary reversals of life-history modes in plethodontids. I conclude that the new molecular data are concordant with morphological and life-history data supporting a phylogeny of plethodontids in which the biphasic life cycle is ancestral at the family level as well as in *Desmognathus*. This requires a minimum of five independent transitions from a biphasic life cycle to direct development, but no reversals.

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Insight into migration patterns of bull sharks in the South Pacific

Data on habitat use and seasonal movements are essential for designing conservation strategies, yet such data are rarely available for large marine animals such as sharks. In this study we equipped eleven bull sharks, *Carcharhinus leucas*, from a Fijian population with pop-up satellite tags to test the hypothesis that bull sharks migrate into nursery grounds. Individual tags remained attached for two to seven months. The pop-up locations give insight into movement patterns and distribution of bull sharks in the South Pacific. They further underscore the need for international cooperation in devising conservation plans.

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Phallic size variation in yearling alligators exposed to naturally occurring environmental contaminants

We collected alligator eggs from two north-central Florida lakes, one contaminated (Lake Apopka) and the other relatively pristine (Lake Woodruff). We incubated one set of eggs from each lake without treatment. Additional eggs were treated with two concentrations of a mixture of 9 contaminants found at elevated levels in eggs from lake Apopka. Eggs were incubated until hatching and the animals were reared for 1 year. We measured the phalli and clitero-phalli of all yearlings and compared measurements among treatment groups. Historically, male alligators from Lake Apopka have smaller phalli when compared with alligators from Lake Woodruff. Therefore, we hypothesized that introducing compounds previously characterized as estrogenic or anti-androgenic would lead to smaller phalli in exposed animals. Conversely, treated animals and animals from Lake Apopka all had larger phalli and clitero-phalli than control groups. These data suggest that the previously identified environmental estrogens or anti-androgens act as estrogens or anti-androgens in juvenile/adult animals but may be androgenic in developing embryos.

BUBLEY, WALTER J.

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The role of the accessory structure in a simultaneously hermaphroditic fish, sand perch (*Diplectrum formosum*)

Sand perch, *Diplectrum formosum*, is a serranid found along the Atlantic waters of the southeastern United States. Sand perch are simultaneous hermaphrodites in which the gonad (ovotestis) contains both active ovarian and testicular tissue. The ovotestis also contains an accessory structure located at the posterior-most portion, in which hydrated oocytes have been observed. The importance and function of the accessory structure in reproduction is unknown. Testicular and ovarian tissue within each ovotestis are slightly asynchronous from each other preventing self-fertilization, but partially negating the advantage of producing both sperm and egg. This study focuses on the presence or absence of hydrated oocytes in the accessory structure relative to the reproductive stages of the ovarian and testicular tissue present in the ovotestis. The role of the accessory structure in relation to advantages of being a simultaneous hermaphrodite is examined. **STORER ICHTHYOLOGY**

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Dietary patterns of predatory fishes at drifting fish aggregating devices (FADs) in the Indian Ocean

Predatory fishes aggregated around drifting fish aggregating devices (FADs) in the Indian Ocean were collected to investigate their trophic ecology, and determine whether they feed on fauna associated with the drifting FADs. Stomach content analysis of yellowfin tuna (*Thunnus albacares*), dolphinfish (*Coryphaena hippurus*), and wahoo (*Acanthocybium solandri*) collected in fall and spring reveal various interesting patterns. A clear seasonal dietary shift is observed for all three species, with diets dominated by pelagic crustaceans in the fall and epipelagic fish in the spring. A high amount of diet overlap between all three predatory species occurred in the fall. Stomach fullness was not correlated with time of collection, indicating no lack of rigid diel feeding patterns. None of the three predatory species fed on fish species (i.e. *Canthidermis maculatus*, *Kyphosus spp.*, *Decapterus spp.* and *Seriola rivoliana*) also aggregated in large numbers around drifting floating objects planted by tuna purse-seiners.

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Phylogenetic relationships of North American phoxinins (Actinopterygii: Cyprinidae) as evidenced by the S7 and Rag1 nuclear sequences

Previous phylogenetic hypotheses of North American phoxinins have been derived from both morphological characters and sequence variation of mitochondrial genes. While various relationships have been proposed based on morphological traits, mitochondrial genes have strongly supported a subset of these relationships. In this study nuclear DNA sequence data from intron 1 of S7 and exon 3 of RAG1 are used to evaluate the evolutionary relationships of North American phoxinin cyprinids. Results of parsimony and bayesian analyses of the individual and combined data sets recovers three monophyletic clades consistent with the open-posterior myodome (OPM), creek chub - plagopterin, and western clades reported in previous studies. Within the shiner clade of the OPM clade *Erimonax monachus* is the basal sister group to a clade inclusive of *Cyprinella*, *Codoma*, *Opsopoeodus*, and *Pimephales*. *Hybognathus* is part of a clade inclusive of *Notropis* and *Notropis harperi* is sister to *Pteronotropis*. Also within the OPM clade, *Erimystax* and *Phenacobius* form a sister group relationship as does *Clinostomus* and *Richardsonius*. Within the creek chub - plagopterin clade *Hemitremia* and *Semotilus* form a sister group relationship. *Orthodon* and *Phoxinus* are basal to the remainder of the taxa that form the western clade.

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Life history of chicken turtles (*Deirochelys reticularia*)

Over the last decade and a half, a life history and demographic paradigm for turtles has emerged. Turtle life histories are characterized by high annual adult survivorship, extended longevities, long reproductive lifetimes, delayed sexual maturity, low annual fecundity, variable and low nest survivorship, and high average juvenile survivorship. Examination of mark-recapture data collected on the Savannah River Site over 31 years (1967-1998), indicated that chicken turtles (*Deirochelys reticularia*) are shorter-lived than any other turtle species studied. We combined data from an intensive four-year study of a chicken turtle population with the long-term survivorship and reproductive data to compare the life history of chicken turtles to the general patterns observed and reported for other turtles. The observations of small females producing small eggs rather than delaying reproduction until they attain a larger body size, a winter nesting period, a carnivorous diet maintained throughout life, rapid growth rates of juveniles, and early maturity of males collectively suggest a life history strategy aimed at optimizing fitness in a seasonal and unpredictable environment.

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Trophic ecology of the common map turtle (*Graptemys geographica*): an isotopic investigation

In common map turtles (*Graptemys geographica*), females are mollusc specialists, whereas males have a broader diet. The invasion of zebra mussels (*Dreissena polymorpha*) has disrupted the trophic structure and mollusc fauna of freshwater ecosystems and may have altered the trophic ecology of common map turtles. We used stable carbon isotopes to investigate the trophic ecology of common map turtles in an Ontario lake severely infested by zebra mussels. The mean $\delta^{13}\text{C}$ of pelagic primary consumers (zebra mussels) was -29.43‰ . Littoral primary consumers had $\delta^{13}\text{C}$ values of -19.87‰ for snails (*Viviparus georgianus*), -19.77‰ for trichoptera (*Nectopsyche* sp.) and -20.40‰ for Ephemeroptera (Heptageniidae). Mean $\delta^{13}\text{C}$ values of adult males, juvenile females (overlapping in size with males), and adult females were -20.33‰ , -22.26‰ and -24.86‰ respectively. A two-source mixing model showed that the diet of males, juvenile females and adult females was composed of pelagic prey at 5%, 24%, and 52% respectively. Zebra mussels having almost extirpated native mussels in our study lake, the pelagic contribution to the diet of females is coming from zebra mussels. Diet analyses conducted before the invasion of zebra mussels have found snails to be the most important food item consumed by female map turtles. Our results suggest that the availability of zebra mussel has partly shifted the diet of female map turtles from the littoral to the pelagic foodweb.

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Ancestral area and divergence date estimation for lampropeltine snakes

The fossil record of ancestors of extant colubroid snake families and subfamilies prior to the Miocene is almost non-existent. Combining techniques of ancestral area and divergence date inference using phylogenetic estimates from extant taxa and calibration references from the Miocene fossil record permits greater confidence in assessing areas and dates of origin for ancestors of modern taxa. In North America, one of the most conspicuous and ecologically, behaviorally, and morphologically diverse group of snakes are the Lampropeletini (*Arizona*, *Bogertophis*, *Cemophora*, *Lampropeltis*, *Pantherophis*, *Pituophis*, *Pseudelaphe*, *Rhinocheilus*, *Senticolis*, and *Stilosoma*). This monophyletic tribe of 29 species is well-represented in the fossil record throughout the middle and late Miocene, and is known to be closely related to Old World (OW) ratsnakes (*Coelognathus*, *Coronella*, *Elaphe*, *Euprepriophis*, *Gonyosoma*, *Oocatochus*, *Oreophis*, *Orthiophis*, *Rhinechis*, and *Zamenis*). Using scnDNA and mtDNA sequences and maximum likelihood (ML) and Bayesian inference (BI) methods of phylogenetic inference, we (i) determined the most probable OW sister taxon of the Lampropeltini, (ii) inferred ancestral areas of origin for lampropeltinines and OW ratsnakes by

applying divergence-vicariance analysis and ML methods of area reconstruction, (iii) estimated divergence dates with penalized likelihood rate smoothing, and (iv) examined rates of color pattern evolution using ML and BI methods of character state mapping. We also relied on these ancestral area and divergence date estimates to assess whether the ancestors of modern-day lampropeltines crossed from the OW to North America using the the trans-Atlantic or the trans-Beringian dipersal route.

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Courtship, mating, and alternative reproductive tactics in the Middle American Dwarf Boa, *Ungaliophis continentalis*

Reproductive behavior has not been documented in detail for either species of the cryptic Central American snakes of the genus *Ungaliophis*. Here we report on courtship of *Ungaliophis continentalis*, a species ranging from Chiapas, Mexico to northern Nicaragua. In February and March 2004, we observed a total of nine courtship encounters involving three males and two females. Males performed two distinct courtship patterns: a passive courtship pattern that was similar to that reported in other snake species and an assertive courtship pattern that featured a tail bite. Eleven behavioral acts performed by males were defined, of which four were unlike those reported for other snake species. This study revealed several interesting aspects of reproductive behavior in *U. continentalis* that appear to be related to individual males being capable of adjusting courtship tactics to bring about successful copulation. These include coercive reproductive behaviors such as the tail bite, the only courtship behavior reported in snakes to occur in a continuous, non-interrupted fashion from the first phase of courtship until dismount.

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Status of a relocated Gopher Tortoise population: One generation later

Relocations are sometimes used in the conservation of reptiles. However, success of most relocations have not been evaluated adequately due to the lack of long-term monitoring post-relocation. Here we report on a population of gopher tortoises (*Gopherus polyphemus*) 16 to 17 years after relocation. Eighty-three tortoises were relocated to Okeehchee County Park (OCP), Palm Beach Co., Florida, U. S. A. in 1985 and 1986. The initial follow-up in 1986 and 1987 found preliminary evidence of success. During 2002 we exhaustively surveyed OCP for all gopher tortoises and their burrows. We found 95 individuals and 290 burrows. Thirty-eight of these were relocatees from 1985 and 1986, indicating both that many individuals continued to persist at OCP, and that new individuals were present. It appears many relocated tortoises left OCP in the first year after relocation, but that those that remained during the first year also stayed long term, and grew at rates normal for the region. Reproduction is

occurring, but egg survivorship is so low that there appears to be very little recruitment. We conclude that this relocation has been successful by some standards, but the low numbers of juveniles suggests that management is needed to promote recruitment.

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**A model of reproductive behavior in the North American cyprinid genus
*Cyprinella***

A model of spawning behavior is proposed for the genus *Cyprinella*, the second largest genus of North American minnows (30 species). Insofar as known, all members of the genus lay eggs in narrow crevices or fissures in rocks and wood. The red shiner *C. lutrensis* is the only species known to exhibit behavioral plasticity, but it readily spawns in crevices. Crevice spawning is reported in three other North American genera: *Erimonax monacha*, *Hesperoleucus symmetricus*, and *Dionda dichroma*. Crevice spawning is a complex social interaction. The salient feature of crevice spawning is social organization that is dependent on an alpha male defending a crevice. In-depth study of digital videotapes of spawning in small aggregations (4 males: 12 females) of *C. caerulea* and *C. lutrensis* fostered recognition of common behavioral organization and formulation of a model for crevice spawning. The model (or ethogram) accommodates existing observations of *Cyprinella* spawning. The 40+ spawning behaviors are organized into functional classes: non-spawning, social-sorting, aggression, courtship, and spawning. The behavioral classes are organized in a natural hierarchy representing a daily spawning cycle. Within the two intensely studied species, shared and unique (possibly species specific) behaviors were identified. The crevice functions like a lek, an intense behavioral arena in which the tumult of aggression and retreat occasionally results in a spawn. To date, complex spawning behaviors are considered to have evolved independently in North American cyprinids, based on convergence of spawning modes. Social organization may be a more informative way to compare behaviors. However, there is no free lunch; such studies necessitate repeated observations of small assemblages to determine social structure.

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Revision of the American Fisheries Society list of imperiled freshwater and diadromous fishes of North America.

The American Fisheries Society Endangered Species Committee is compiling the third list of imperiled freshwater and diadromous fishes of North America (Mexico, Canada, and the United States). The first AFS list, using standardized definitions and listing criteria developed by the committee, was published in 1979 and assigned 251 species, subspecies, and undescribed taxa among three conservation categories. A decade later, the 1989 list reached 364 species, subspecies, and undescribed taxa, by adding 139 new taxa and removing 26 from the previous list. The forthcoming list may exceed 800 species, subspecies, populations, and undescribed taxa divided among five conservation categories: endangered, threatened, vulnerable, extirpated, and extinct. What are the reasons for such a large increase in the number of imperiled taxa? The 15-year hiatus since the last list corresponds to significant advances in phylogenetic analysis, population genetics, modifications of species concepts, new investigative methods, nomenclatural revisions, increased knowledge of the composition and status of faunas (especially for Mexico), and exponential increases of threats. Discovery of new taxa and diversity has increased; about 19% of imperiled taxa are undescribed species and evolutionarily distinct populations (ESU). Overall, imperilment of the North American freshwater and diadromous fish fauna is escalating, primarily among three general assemblages: large-river fishes, anadromous salmonids, and small fishes with limited ranges.

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First report of an intromittent organ in an inseminating characiform genus

We herein document, for the first time, true intromittent organs in four populations of inseminating fishes of the family Characidae, genus *Monotocheiroidon*, which appear to comprise at least two new species. All females histologically analyzed from these populations, as well as a female of the described species, *Monotocheiroidon pearsoni*, had spermatozoa within the ovary, confirming insemination. Male *M. pearsoni* produced aquasperm with spherical nuclei (diameter 1.6 μ m), with no intromittent organ being evident. On the other hand, males from the new populations of *Monotocheiroidon* produced spermatozoa with slightly ovoid to elongate nuclei (lengths 1.8-4.1 μ m) and possessed distinct intromittent organs. Those with more elongate sperm nuclei had longer intromittent organs. Each intromittent organ consisted of an elongate extension of the body wall encompassing an extension of the sperm duct, which opened to the outside at the pointed tip of the organ. Skeletal muscle cells are present throughout the organ. At the base, the skeletal muscle is oriented around the organ (circular) possibly forming a sphincter. The skeletal muscle along the organ is mainly oriented longitudinally, although some circular bundles are present. These males are apparently able to manipulate the organs by means of this muscle. The wall of the sperm duct within the organ is thrown into folds and is lined with a low cuboidal epithelium. Degenerate sperm cells were found within the sperm duct along the intromittent organ. The posterior portion of the testes of these males lacks spermatogenic tissue and serves as an open storage region for mature spermatozoa.

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Second edition of Peterson Field Guide to Freshwater Fishes, Part I: What it tells us about fish diversity.

The 1st edition of the *Peterson Field Guide to Freshwater Fishes of North America North of Mexico* was published in 1991 and contained accounts for 790 species. The 2nd edition, to be published 15 years later, will contain accounts for about 890 species and allows us to examine how our fish diversity has changed. About sixty-five of the additional 100 species are newly described or recognized native populations, and 35 are newly established exotics. These dramatic increases reveal much about our biota, our view of species-level diversity, and changes in our environment. An analysis of data in the guide provides information on where these additional species are geographically and ecologically located, and which higher-level taxa are changing in species-level diversity. We also will examine trends related to subspecies, nomenclature, higher-level taxa, endangered species, and extinctions.

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**Control and eradication of exotic ticks introduced into the United States
on imported reptiles**

Since 1962, at least 29 species of exotic ticks have been introduced into the United States on imported reptiles. Some of these exotic tick species have developed breeding colonies in Florida and have infested other reptilian species in captivity, indicating that some species could become established in Florida and elsewhere in the United States with unknown risks for native reptilian populations. While a few are known to be vectors of important diseases of veterinary or public health significance, nothing is known about the pathogenic effects or vector potential of most of these exotic tick species. However, one species (*Amblyomma sparsum*), infesting a shipment of leopard tortoises (*Geochelone pardalis*) imported into Florida from Zambia in 1999, was found to be infected with the rickettsial bacterium *Ehrlichia (Cowdria) ruminantium* that causes heartwater, an acute disease of domestic and wild ruminants such as deer. In order to minimize risks associated with the introduction of these exotic ticks, practical protocols were developed for the control of ticks on infested reptiles and for the eradication of ticks from infested premises. Protocols for control of ticks utilized a formulation of permethrin (Provent-a-mite™) specifically developed for use on reptiles; tortoises were treated directly while snakes and lizards were treated indirectly by spraying of the substrate in their containers. Protocols for eradication of ticks involved treatment of reptiles with permethrin and concurrent treatment of the premises with cyfluthrin for tortoise facilities or permethrin for snake or lizard facilities. Using these protocols, an *A. sparsum* tick infestation was successfully eradicated from a tortoise facility and an *Amblyomma (Aponomma) komodoense* tick infestation was safely eradicated from a Komodo dragon (*Varanus komodoensis*) exhibit at a zoo.

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**Morphology and phylogenetic implications of Recent and fossil
carcharhiniform shark vertebral centra**

The cross-sectional anatomy of secondary calcifications of shark vertebral centra has featured in phylogenetic hypotheses, although never in a rigorous cladistic framework. In this study, the internal calcification patterns, along with the external morphology, of fossil and Recent shark centra of the Order Carcharhiniformes have been coded and subjected to a cladistic analysis to address the utility of centrum features for revealing relationships. Carcharhiniform sharks were selected as a study group because they are a monophyletic clade with reasonably well understood intraordinal relationships, a rich fossil record, and readily available Recent comparative skeletal material. The external characters evaluated include centrum proportions, the presence and distribution of cartilage canals, and the size, shape, and spacing of the foramina for the basidorsal and basiventral arch components. The internal calcification features evaluated include the morphology and spacing of the four intermedialia,

the four noncalcified areas, and the four diagonal calcifications. Centrum characters were analyzed both separately and combined with additional morphological characters from previous analyses. Results of the cladistic analysis show that shark centrum characters are useful for elucidating phylogeny. Tree topology was very similar for both analyses, and similar to recent molecular databased phylogenies. The addition of centrum data to shark phylogenetic analyses will allow for a more objective means of determining the interrelationships of fossil and extant carcharhiniform sharks than studies based on teeth alone, with their well-documented difficulties. The data gathered will also be important for future studies to interpret the relationship between centrum morphology and swimming characteristics in extant, and ultimately, extinct taxa.

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Revision of the Ponyfish Genus *Gazza* (Teleostei: Leiognathidae)

Gazza is a member of Leiognathidae, a clade of bioluminescent fishes that exhibits a symbiotic relationship with the bacterium *Photobacterium leiognathi*, which they house in a circumesophageal light organ. It is hypothesized that bacterial luminescence functions to deter predators, locate prey, coordinate schools, and presumably also to signal potential mates. Five species currently comprise the genus, although intrageneric relationships remain unresolved and the taxonomic status of most nominal species remain uncertain, given that species diagnoses were not based on apomorphic features. Species identifications have primarily relied on squamation patterns on the anterior flank and the shape of the subocular silvery region, both of which are traits that exhibit little interspecific variation. Using these features, as well as several novel traits revealed in a previous study, three undescribed species are identified and briefly described. Diagnoses are presented for all species of *Gazza*, as well as a key to species. A phylogeny for *Gazza* is presented, in which the three new species are placed and interspecific relationships are resolved.

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Natural fragmentation of salamander populations due to moisture gradients

The fragmentation of salamander populations can occur as a result of land use. Forest fragments surrounded by developed land often lack salamanders. Natural fragmentation of salamander populations may occur in eastern hardwood forests as a result of moisture gradients because salamanders are moisture dependent. Streams and their associated mesic valleys may act as corridors for migration of salamanders. We examined this natural fragmentation by comparing salamander species diversity and abundance under twenty-four plots within Mammoth Cave National Park. Each plot contained 20 coverboards. We placed eight plots in each

of three distinct habitats; ridgetops, streamsides, and sinkholes. Increased species presence and frequency correlated with damper landscapes. The moist valleys surrounding streams may act as functional passageways between fragmented salamander populations. **STORER HERPETOLOGY**

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Effectiveness of bycatch reduction devices on crab pots at reducing Diamondback Terrapin capture and mortality

Diamondback terrapins (*Malaclemys terrapin*) drown in blue crab (*Callinectes sapidus*) pots throughout their range. The objectives of this study were to: 1) test if bycatch mortality of diamondback terrapins in commercial crab pots is reduced by using bycatch reduction devices (BRDs); 2) determine if BRDs enhance crab catch in Florida by comparing sex, size, and number of blue crabs captured in standard crab pots with those captured in pots equipped with BRDs; 3) formulate recommendations to Florida Fish and Wildlife Conservation Commission for regulations that reduce terrapin bycatch mortality in Florida waters. We fished 15 control pots and 15 pots with BRDs (experimentals) for 10-day periods in each of six Florida counties from 2002 through 2004. Pots were baited and checked daily. We determined sex of all captured terrapins and blue crabs and took measurements of each that would allow us to evaluate if BRDs affected the size of either species. Thirty-seven terrapins were caught in control pots and four in experimentals. Several were small enough that they would not have been prevented from entering either pot treatment, but we found that 73.2% of the terrapins in this study could have been prevented from entering crab pots with functional BRDs. There were no significant differences between the sex, number, or measurements of legal-sized crabs captured in control and experimental pots at any of the study sites. We will present this data combined with data from two additional counties we will study in May 2005. We recommend that Florida Fish and Wildlife Conservation Commission devise and adopt regulations that require the use of 45.0 x 120.0 mm BRDs on all commercial and recreational crab pots in Florida as soon as possible.

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The effects of flow augmentation on the fish community of a Virginia trout stream

We examined the impacts of flow augmentation on the fish community and physical habitat in a historically dewatered segment of the Dan River in southwestern Virginia. We compared the overall fish community structure and

selected population parameters between pre and post flow augmentation years. The a priori expectation was that the increase in flow (from 0.06 cm/s to 0.25 cm/s) would lead to a corresponding increase in both the number of fish and the number of species. We saw no significant change in overall diversity. However, we did observe a decline in Margalefs Diversity Index. Total fish biomass (g/m²) increased following flow augmentation. Mean total biomass (all species combined) increased from 6.08 g/m² to 7.69 g/m² between low flow years and augmented flow years (ANOVA; P=0.0197). Total biomass increased in pools and riffles, but was only statistically significant in riffles (ANOVA; P=0.1911 and P=0.0097, respectively). We found no significant relationship between stream discharge and either the numbers or biomass for most species. However, we did observe a significant increase in density of bluehead chubs and significant increases in both density and biomass of margined madtoms and brown trout. We compared recruitment success of brown trout before and after flow augmentation. The abundance of age 0 brown trout was utilized as a measure of recruitment success and indicates that brown trout recruitment increased dramatically following flow augmentation. Margined madtoms, bluehead chubs and brown trout represent the higher level predators in this stream fish community. Their significant increase in biomass and densities may be indicative of top down control in this stream fish assemblage.

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Do frogs choose ponds with fewer competitors and fewer predators?

The primary goal of this research is to determine if amphibians choose to lay eggs in ponds that have fewer competitors and predators than in adjacent ponds that have neither. Our initial hypothesis is that given a choice, amphibians will choose ponds that have fewer competitors and predators. We sampled 9 small ponds in a field along a tree line at Saint Louis University's Lay Center located in Pike County, Missouri. The ponds are 4 x 4 m and approximately 0.7 m deep and are lined with a rubber pond liner. The ponds received one of three treatments in a randomized order. Three of the ponds were stocked with 125 bullfrog tadpoles (*Rana catesbeiana*), three of the ponds were stocked with sunfish (*Lepomis*), and three ponds served as controls. The data for the first two years of this study are similar. All treatment groups were statistically similar in April and May. However, in June, - August the fish treatment ponds had statistically fewer tadpoles compared to tadpole and control treatment ponds. More field work will be needed to determine if adult frogs chose different ponds or fish predation accounted for the differences observed.

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Chondrichthyan growth studies: An updated review, stressing terminology, sample size sufficiency, validation, and curve fitting

Validated age and growth estimates are important for constructing age-structured population dynamics models of fishes, including chondrichthyans, especially those that are exploited. We will review, correct, and supplement the results from the recent chondrichthyan ageing summary chapter, stressing the structures (both traditional and novel) utilized to estimate ages and synthesize the terminology used to describe their growth features. We will discuss validation approaches, concentrating on edge and marginal increment analyses. We will propose methods to assess size-specific sample sufficiency. We will review the mathematical approaches used to produce and interpret validated growth parameters, stressing the incorporation of size at birth (L0). We will briefly summarize results from recent studies among taxonomic groups, stressing the patterns in growth and longevity parameters, how useful they are for age-structured models and resulting management policies for assessing the status of exploited chondrichthyan populations.

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Bomb dating and age determination of spiny dogfish

Bomb radiocarbon has previously been used to validate the age of large pelagic sharks based on incorporation into vertebrae. However, not all sharks produce interpretable vertebral growth bands. Here we report the first application of bomb radiocarbon as an age validation method based on date-specific incorporation into spine enamel. Our results indicate that the dorsal spines of spiny dogfish (*Squalus acanthias*) recorded and preserved a bomb radiocarbon pulse in growth bands formed during the 1960s. Through comparison of radiocarbon assays in young, known-age dogfish collected in the 1960s and 1970s with the corresponding growth bands in old dogfish collected later, we confirm the validity of spine enamel growth band counts as accurate annual age indicators to an age of at least 45 yr. Radiocarbon incorporation into North Sea dogfish spines occurred in similar years as those in the northeast Pacific, although the amount of radiocarbon differed in keeping with the radiocarbon content of the water. Based on the age-validated spines, the growth rate of spiny dogfish in the northwest and northeast Atlantic is substantially faster, and

the longevity is substantially less, than that of dogfish in the northeast Pacific.

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Are we Nero fiddling while Rome is burning? Addressing the issue of introduced reptiles and amphibians instead of documenting a slow decline

Herpetologists need to take action rather than quietly documenting a deteriorating situation related to introduced amphibians and reptiles. There needs to be broader recognition that non-native reptiles and amphibians can and do have ecological and economic costs associated with them. The expansion of human populations and the associated increase in trade globally has had detrimental impacts to many reptile and amphibian species worldwide through habitat destruction, commercial harvesting for food, the pet trade, and the spread of pathogens. Concomitantly, a smaller subset of herps have increased in abundance and range as human trade in, and accidental transport of, these species has increased worldwide. If the upward trend of exotic herpetofaunal introductions continues there is a reasonable likelihood that future generations of herpetologists will be able to study a generic commensal herpetofauna that is similar in all cosmopolitan sub-tropical and tropical areas worldwide. In essence, certain reptile and amphibian species are likely to have global distributional patterns that mirror common weedy plants and rodents belonging to the genus *Rattus*. I will review non-regulatory and regulatory approaches to address this issue and the need to expand efforts to monitor for the introduction of high-risk species in ecologically sensitive sites and implement eradication programs that are planned prior to any potential introduction into these sites. At the individual level, herpetologists need to report observations of alien herps to local natural resource agencies and make an effort to publish these observations in publications such as the Herpetological Review. If feasible the distribution of alien herps should be delineated and localized populations controlled. A user friendly clearinghouse for methods for detection and capture of herps (alien or not) needs to be established. Additional research is needed into the role commerce plays in the spread of alien amphibians and reptiles through different pathways.

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Established introduced lizards: A boundless supply of biological material

Introduced species have been used as indicators of environmental contamination in aquatic ecosystems for decades; however, they have not been utilized as sentinels of environmental quality in terrestrial ecosystems. More than 30 species

of introduced lizards have established, reproducing populations in the United States, and most of these species are thriving in Florida. Introduced lizards provide valuable opportunities for applied research once they have become established with little possibility of eradication. Characteristics that make introduced lizards successful invaders also make them suitable for use as indicators of environmental contamination. They are often common, prolific, adaptable to many habitat types, and can live in degraded and disturbed areas. We review the feasibility of using lizards that have been introduced, are closely related to species that have been introduced, or have the potential of being introduced to the United States as indicators of heavy metal contamination. Metal concentrations in lizards were compared from the few known, available studies. Differences were found in metal concentrations in lizards from different locations within a given region, and lizards from sites presumed to be contaminated by heavy metals contained higher metal levels than those from locations that were uncontaminated. Brown anoles (*Anolis sagrei*), tropical house geckos (*Hemidactylus mabouia*), sand lizards (*Lacerta agilis*), common viviparous lizards (*Lacerta vivipara*), common wall lizards (*Podarcis muralis*), and starred agamas [*Laudakia (Agama) stellio stellio*] were shown to be suitable indicators of heavy metal contamination. Introduced lizards provide convenient packages of biological material that can be analyzed to determine the contamination of the environment, especially in Florida, where many species occur and state collection permits are not required.

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Roles of local stakeholders in managing introduced Nile monitors in Florida

Basic research on introduced species is important, but there is a point where we need to stop studying them and start eradicating them. Stakeholders with a vested interest in eradication have often been employed in such efforts with great success. We studied the efficacy of using local stakeholders in efforts to eradicate introduced Nile monitors (*Varanus niloticus*) from residential areas of Cape Coral, Florida. In July 2003, we initiated a pilot eradication program using press releases in local media outlets to educate the public about the problem and generate lizard sightings. Lizards were captured with Havahart traps, ethically euthanized, and preserved for morphological, dietary, parasite, and reproductive cycle analyses. Interactions with the media (phone calls, interviews, site visits, follow-ups, etc.) required a massive time investment, but the benefits far outweighed the costs. Over 100 lizards were captured as a direct result of public input. The frequency of reported lizard sightings peaked a few days after each press release, decreased rapidly thereafter, and reached a baseline frequency within a few weeks. However, the baseline frequency of reports increased over time, and calls to local police and animal control declined over time, indicating we effectively educated stakeholders. One local press release was picked up by the Associated Press, resulting in national and international exposure of the

project in newspapers, magazines, internet sites, and on television. Regional, national, and international media served to educate the public about the effects of introduced species and resulted in reports of monitors outside Cape Coral, but did little to increase reports of monitors in Cape Coral. Local press releases were the driving force behind the success of our emergency response efforts. Local media can greatly assist emergency response and eradication efforts and should be considered a viable option, especially when conspicuous, charismatic megafauna are involved.

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Wetland conservation and the spatial ecology of the Red-bellied Watersnake (*Nerodia erythrogaster erythrogaster*)

The amount of terrestrial habitat surrounding wetlands for wildlife use is an important and unresolved issue in wetland conservation. In an attempt to answer questions about terrestrial core habitat width, I used radio-telemetry to study movements and terrestrial habitat use of red-bellied watersnakes. Seventeen (10 females and 7 males) adult *Nerodia erythrogaster* were fitted with surgically implanted radio-transmitters from 2001-2004 at one study site in the upper coastal plain of South Carolina. Minimum convex polygon home ranges were 0.78-55.89 ha and kernel home range estimates were 3.24-123.88 ha. Snakes went up to 909 m from wetlands and stayed out of wetlands for up to 61 days. Terrestrial habitats preferred by red-bellied watersnakes included pine forest, southern mixed hardwood forest and pine plantations. Terrestrial habitat width around wetlands should be about 400m to encompass 95% of terrestrial localities observed in this study.

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AmphibiaTree

The AmphibiaTree project encompasses three avenues of data collection: 1) sequence data for mitochondrial ribosomal genes for as many species as possible, and for a variety of nuclear genes (e.g., 18S, 28S, rhodopsin, RAG-1, RAG-2) for a subset of taxa, 2) integration of information about morphological diversity of living and fossil species will be collated, and new data from computed tomography will be incorporated, and 3) sampling in biodiversity hotspots to account more completely for amphibian diversity. Analyses will include collaborative phylogenetic studies of the three living amphibian clades, integrating molecular and morphological datasets with characters from fossil taxa. The bioinformatics component includes 1) development of AmphibiaWeb (amphibiaweb.org), a one-stop information center, including web pages for every species, information on amphibian declines, and discussion forums; 2) populating the pages of the amphibian branches of the Maddisons' Tree of Life project (tolweb.org) with information about higher taxa.

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Effects of habitat loss on Argentine Boa Constrictor (*Boa constrictor occidentalis*) populations

Identifying how habitat loss and fragmentation affect species ecology is a critical step in designing conservation strategies. Dispersal is one of the main processes influenced by the spatial and temporal distribution of critical resources in the landscape. In order to evaluate if habitat features could affect gene flow in populations of *Boa constrictor occidentalis*, which is a threatened species of South America herpetofauna included in the Appendix I of CITES, we characterized landscape physiognomical vegetation composition in two areas of Córdoba province, Pocho and Sobremonte, and related it with the population dispersal levels from each area. Using a geographic information system with Landsat 5 TM satellite images and performing field visits, we developed a supervised classification to identify and quantify the habitat composition of the study areas. Considering that our previous studies about habitat use indicate forest as the most suitable environment for the Argentine Boa Constrictor, we measured the fragmentation of this vegetation structure. We also calculated levels of dispersal using allozymes and ISSR-PCR as molecular markers to estimate gene flow in both areas. The supervised classification revealed that Sobremonte maintains greater forest coverage percentage than Pocho. Besides, the fragmentation analysis indicated that the forest patches are larger and nearer in Sobremonte. According to these results, gene flow was higher in Sobremonte than in Pocho suggesting that levels of dispersal in *B. c. occidentalis* decrease due to the fragmentation of suitable habitats. In consequence, the present tendency of changing in the Gran Chaco landscape, that is characterized by the intensification of farming and exploitation of natural woodland areas, could be a major reason for populations of Argentine Boa Constrictor become isolated.

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Reproductive behavior in a free-ranging population of Mohave rattlesnakes (*Crotalus scutulatus scutulatus*)

Despite many studies of its venom, few researchers have investigated the natural history of *Crotalus s. scutulatus* (Mohave rattlesnake). This radiotelemetry study of a California population produced > 3700 encounters with 80 free-ranging specimens between August 2001 and November 2004. A bimodal mating pattern was observed, with 13 pairs engaged in reproductive behavior between 21 August and 7 October, including accompaniment ($n = 3$), courtship ($n = 7$), and coitus ($n = 3$) and 18 similar observations between 16 March and 16 May, including trailing ($n = 1$), accompaniment ($n = 5$), courtship ($n = 7$), and coitus ($n = 5$). Only one incidence of reproductive behavior was observed in 2002 (September courtship) during a rainfall season that produced only 28% of mean (1971-2000) precipitation. Spring courtship occurred a month later in 2003 (April-May) than in 2004 (March-April), despite nearly identical mean emergence dates

(11 March and 10 March, respectively), possibly due to dehydration that was resolved by heavy rain on 16 March 2003. During the 2003 and 2004 reproductive seasons, mean daily movement of males (47 meters/day \pm 6.93 SE) was more than 3 times that of females (14 meters/day \pm 2.36 SE) (independent *t*-test, $P = 0.001$). Mean monthly movement (both sexes combined) showed significant correlation with the number of reproductive pairs observed per month (Pearson's $r = 0.445$, $P = 0.001$). Utilizing only specimens with ≥ 365 d continuous data (mean 745 d; range 370-953), males ($n = 6$) were found to occupy much larger areas than females ($n = 8$) (independent *t*-test, $P = 0.001$); mean estimated home ranges (95% fixed kernel method) were 20.4 ha (\pm 2.59 SE) and 2.2 ha (\pm 0.43 SE), respectively. Neonates appeared in late August and September and data suggest that males and females are sexually mature at ca. 16-20 and 25 months, respectively.

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Long-term trends in elasmobranch catch composition from fishing derbies in Elkhorn Slough, California

Long term trends in the elasmobranch assemblage in Elkhorn Slough, Monterey Bay, California, were analyzed by documenting species composition and catch-per-unit-effort (CPUE) from 55 sport fishing derbies during May, June and July, from 1951 until 1995. The most abundant species, bat rays (*Myliobatis californica*), shovelnose guitarfish (*Rhinobatos productus*) and leopard sharks (*Triakis semifasciata*), were also analyzed for size-weight relationships, trends in size class distributions, stage of maturity, and sex ratios. Changes in species composition over the course of the derbies included the near complete disappearance of shovelnose guitarfish by the 1970s and a slight increase in the abundance of minor species (mainly smoothhounds, *Mustelus* spp., and thornbacks, *Platyrrhinoidis triseriata*) starting in the mid-1960s. The proportion of bat rays in the catch steadily increased over the years while the abundance of leopard sharks has declined slightly during the last two decades. A peak in overall CPUE was evident during the mid to late fifties. Leopard shark and bat ray size class distribution data showed no obvious changes. The catch of bat rays and leopard sharks was consistently dominated by immature individuals, while the catch of shovelnose guitarfish was heavily dominated by adults. Female bat rays and shovelnose guitarfish were larger than their male counterparts, and outnumbered males nearly 2:1. Female and male leopard sharks were more nearly equal in size and sex ratio. Changes in species composition are likely due to shifts in the prevailing oceanographic conditions and habitat alteration in Elkhorn Slough. The sex ratios, stage of maturity, and size class distributions provide further evidence to the theory that Elkhorn Slough functions as a nursery ground for bat rays and leopard sharks. **AES GRUBER**

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Spatial and temporal patterns of movement and habitat utilization of female leopard sharks in Elkhorn Slough, California

The leopard shark (*Triakis semifasciata*) is one of the most abundant nearshore sharks in California and is commonly found in bays and estuaries. Elkhorn Slough is a shallow tidal embayment at the edge of Monterey Bay that is extensively utilized by leopard sharks of all ages and is believed to function as a nursery ground for the species. Due to the important role of the Slough in the life history of leopard sharks, understanding how sharks utilize this environment is important. Patterns of movement and habitat use of female leopard sharks in Elkhorn Slough were examined using acoustic tags and a combination of manual tracking and passive monitoring techniques between May 2003 and February 2005. Ten leopard sharks (91-132 cm TL) were tagged and manually tracked for 20-71.5 hours. An additional 13 leopard sharks (78-140 cm TL) were tagged and monitored for 4-443 days using an array of acoustic receivers. Analyses done to date indicate that the Elkhorn Slough National Estuarine Research Reserve marsh restoration site is important for leopard sharks in Elkhorn Slough. Tagged sharks spent extensive amounts of time in several specific areas during the pupping season, providing evidence of the value of the reserve as a nursery ground. Shark movements and habitat use appeared to be tidally influenced, because movements of tagged animals were restricted to channels and tidal creeks at lower tides. As the tide increased, they moved out of the channels onto intertidal mudflats where they appeared to utilize low intertidal mudflats. When in the main channel of Elkhorn Slough, shark movements showed more diel periodicity. Tagged animals moved up and down the Slough at relatively regular intervals, in which the sharks primarily occurred in the lower slough during night. **AES CARRIER**

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Growth dynamics of the Spinner Shark, *Carcharhinus brevipinna*, off the United States Southeast and Gulf of Mexico coasts: a comparison of methods

The age and growth dynamics of the Spinner Shark in the northwest Atlantic Ocean off the Southeast United States and in the Gulf of Mexico were examined and four growth models were used to examine variation in the ability to fit size-at-age data. The von Bertalanffy growth model, an alternate equation of the von Bertalanffy growth model with a size-at-birth intercept, the Gompertz growth model, and a logistic model were fitted to sex-specific observed size-at-age data. Considering the statistical criteria (e.g. lowest MSE, high coefficient-of-

determination, and greatest level of significance) we desired for this study, the logistic model provided the best overall fit to the size-at-age data while the von Bertalanffy growth model gave the worst. When considering biological validity, the von Bertalanffy model for female sharks provided estimates similar to those reported in other studies. However, the von Bertalanffy model was deemed as inappropriate for describing the growth of male spinner sharks because estimates of theoretical maximum size suggested a size much larger than that observed in the field. However, the growth coefficient ($k=0.14$) from the Gompertz model provided an estimate most similar to that reported for other large coastal species. The analysis of growth for spinner shark in this study demonstrate the importance of fitting alternate models when standard models fit the data poorly or when growth estimates do not appear to be realistic.

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Micro-sympatry correlates with rate of morphological evolution in darter fishes (Teleostei: Percidae)

Although biologists have long recognized that clades of species and other monophyletic groups differ in morphological diversity, methodological limitations have largely prevented researchers from identifying the ecological and evolutionary correlates of this variation. Recent improvements in the methods used to quantify and compare morphological diversity among groups, however, now make such studies possible. Here, we measure morphological diversity by calculating rates of change in 10 functionally relevant characters and use a likelihood ratio test to compare rates of morphological change between two clades of darters (Teleostei: Percidae), the snubnose darters (a clade of *Etheostoma*) and the genus *Percina*. We then test whether differences in the rate of morphological change are correlated with patterns of species coexistence, a measure of sympatry at a small geographic scale. Based on an extension of the competitive exclusion principle which states that ecologically identical species cannot coexist for long periods of time, we predict that clades in which a higher proportion of species coexist will have higher rates of morphological change. We use an ecoinformatic approach that includes an analysis of collection databases from four museums and institutions to quantify patterns of species coexistence. We find that *Percina*, the clade in which a higher proportion species coexist, has a significantly higher rate of change in body size and shape than the snubnose darters. Our results provide the first evidence that patterns of species coexistence are correlated with morphological diversity among clades.

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Phylogeography of the freckled python, *Liasis mackloti* ssp., of Indonesia's Lesser Sundas Archipelago based on multiple character analyses

Since Darwin's time, insular populations have played an important role in our understanding of the nature of variation. Empirical studies of natural populations are benefited by a simplified population structure generally observed on islands with reduced or no migration between adjacent islands. Our main goal was to elucidate the geographic patterns of genetic, morphological and behavioral variation in a large predator, the freckled python (*Liasis mackloti* ssp.), in order to gain a thorough understanding of the historic dispersal and/or vicariant events that have shaped the evolution of this subspecies (and likely, species) complex. *L. mackloti* ssp. is currently known to exist on at least five Indonesian islands. Partial and complete mtDNA nucleotide sequences of the cytochrome b gene for each known population of *L. mackloti* were obtained and used to generate a genetically-based phylogenetic hypothesis of this potential species complex. Based on DNA evidence, the five islands represent three well supported clades (and likely species) and exhibit 5-10% sequence divergence when comparing the Roti/Semau/Timor clade with the Sawu or Wetar clades. A phylogenetic tree based on morphological characters was also determined so that derived or ancestral characters could be mapped onto the gene tree. Lastly, behavioral patterns (e.g., presence or absence of male-male combat, variation in courtship behaviors, and ability to discriminate between intra and interpopulational pheromone trails) were observed, statistically analyzed, and parsimoniously mapped onto the genetically- and morphologically-determined phylogenetic hypotheses. These characters were compared to see if there were significant between-data-set incongruencies prior to presenting a final and resolved phylogenetic analyses. Results indicate that morphological, behavioral, and genetic characters are congruent and yield three well-supported clades that not only reveal similar patterns of evolutionary history but provide substantial evidence for recognizing each clade as a new species.

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Why are we still talking about amphibian declines? Symposium introductory remarks

Global amphibian population declines continue to represent a true intellectual challenge to experts in environmental sciences, conservation biology, and herpetology. Notwithstanding recent advances in the field, we have yet to fully understand the underlying processes and the complex interactions among factors leading to amphibian population crashes. In January of 2004, a graduate-level program called *Advanced Training in Amphibian Declines Research* took place in

Costa Rica, gathering 30 graduate and postdoctoral students from 11 countries throughout the Americas. *A New Generation of Research on Amphibian Declines* is a symposium organized by alumni of that program to present, discuss, and further the collaborative and innovative work started in Costa Rica. It brings together young scientists developing cutting-edge research in Africa, Central, North and South America. Symposium speakers come from Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Honduras, Mexico, Panama, Peru, and the United States. Talks include new approaches to the study of pathogen fungi *Batrachochytrium* and of *Saprolegnia* in model systems and wild populations. Special emphasis is given to research across disciplines, including links between chytridiomycosis and pet trade, pesticide effects and declining populations, skin peptides and disease susceptibility, environmental change, pathogen infestation, and amphibian behavior. The symposium also includes talks about new perspectives on the effects of landscape change and human expansion on natural populations, as well as new monitoring approaches and ecological studies of wild pathogen-exposed populations. New data about the status of populations at risk in several Latin American countries are made public for the first time.

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Phylogeography of the Shortfin Scad, *Decapterus macrosoma* (Perciformes, Carangidae) from the Philippines

Previous studies have shown that populations of several species of *Decapterus* have considerable structure within the Indonesian archipelago. We tested for population divergence of the shortfin scad, *Decapterus macrosoma*, across the Philippine archipelago using sequences from the mitochondrial *control region*. These populations show structure that corresponds to the major basins within and around the Philippines. This includes the Philippine Sea, the Sibuyan Sea, the South China Sea, the Sulu Sea, and the Suluwesi Sea. An AMOVA resulted in significant differences ($p < 0.01$) between populations. We examine these results in the context of the unique geological history of the Philippines, both in terms of island integration that occurred throughout the Cenozoic and basin isolation that occurred during the Pleistocene.

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Canopy cover, solar radiation, and temperature dependent sex determination: A predictive model

The sex of an individual with temperature dependent sex determination (TSD) is determined during a critical, thermo-sensitive period of incubation. Many factors, such as soil substrate, amount of sunlight, air temperature, and canopy

cover affect incubation temperatures of nests. Canopy cover directly influences the amount of solar radiation transferred to the nest, which greatly impacts the micro-environment experienced by developing embryos. However, there are no techniques to estimate the sex ratio of a nest without sacrificing individual hatchlings. Our goal was to test whether a predictive model relating transferred solar radiation, determined by site openness, could accurately predict nest sex ratios of painted turtles (*Chrysemys picta*) in western Illinois. We collected hemispherical pictures or densitometer estimates of canopy cover over turtle nests between 1994 and 2004. Site openness and solar radiation estimates were established using the program GLA. The sex ratios were determined for all nests hatching during this time period. Data will be presented comparing individual nest solar radiation estimates with incubation temperatures collected using thermal data loggers. A predictive model will be generated to test whether nest solar radiation estimates, in relation to various air temperature measurements, can effectively predict the sex ratio from nests of an organism with TSD using non-invasive techniques.

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Anguilliform larvae collected off North Carolina

The distinctive larval stage (leptocephali) of eels facilitates dispersal through prolonged life in the open ocean. Leptocephali are abundant off of North Carolina, yet data on distributions and biology are lacking. As part of a larger study, we sampled the whole water column in or near the Gulf Stream off Cape Hatteras, Cape Lookout and Cape Fear, NC. During summers of 1999-2004, leptocephali were collected by neuston net, plankton net, Tucker trawl and dip net from the surface to 1293 m. Additional samples were collected monthly in Onslow Bay, NC (surface-91 m), from April 2000 - December 2001 by bongo and neuston nets, Methot frame trawl and Tucker trawl. We completed 115 tows off Cape Hatteras, 25 off Cape Lookout, 15 off Cape Fear and 53 tows in Onslow Bay. Dominant families for all areas were Congridae, Muraenidae and Ophichthidae. A total of 59 species of eel leptocephali were collected from all areas (combining all methods). The most abundant species collected off Cape Hatteras were *Gymnothorax ocellatus*, *Paraconger caudilimbatus*, *Ariosoma balearicum*, *Callechelys muraena* and *Ophichthus gomesii*. Off Cape Lookout, dominant species were *A. balearicum*, *P. caudilimbatus*, *Rhynchoconger flavus*, *G. ocellatus* and *O. gomesii*. Off Cape Fear, dominant species were *P. caudilimbatus*, *A. balearicum*, *R. flavus* and *G. ocellatus*. Dominant Anguilliform larvae collected in Onslow Bay were *G. ocellatus* and *O. gomesii*. The North Carolina adult eel fauna (estuary to at least 2000 m) consists of 54 species, and our collections represented 52 percent of these. We collected 34 species for which adults are not yet known off North Carolina. Despite Gulf Stream transport and a prolonged leptocephalus stage, many of these eels may not establish successful populations off of or north of the Carolinas.

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Reproduction and mating behavior of the Atlantic flyingfish, *Cheilopogon melanurus* (Exocoetidae), off North Carolina

The reproductive biology of the Atlantic flyingfish, *Cheilopogon melanurus*, was examined off North Carolina during summers of 1991-1992 and 1999-2003. Specimens were collected using a small mesh neuston net and dip nets. A spawning event, the first observation of mating behavior for this species, was recorded off Cape Fear, NC, on 19 August 2003, between 2100 and 2126 hr. It was considered to be a spawning event because of: 1) unusual coloration of both sexes, 2) unusual swimming behavior of both sexes, and 3) ready release of gametes by both sexes upon capture. The spawning event occurred in the presence of small clumps of floating *Sargassum*, but the fish did not appear to use the algae. Over all collections, female gonadosomatic indices were highest in June and July, but mature females were collected each month (June, July, and August). The overall female to male sex ratio did not vary significantly from 1:1. Number of ova increased with increasing fish size, but the relationship was not strong. Our data indicate a spawning season of at least June through August off of North Carolina due to high female gonadosomatic indices, large egg diameters, presence of egg filaments, presence of spent females in July and August, and presence of small juveniles (≤ 25 mm) in July and August. This is the first report of single pair spawning for this family; other species reportedly spawn in large aggregations.

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Red-eared sliders as indicators of ecotoxicological environmental stress over time: An update

There is a paucity of ecotoxicological research focusing on reptiles and amphibians, even though this taxonomic group may provide unique insights into the dynamics of toxicant fate and transport in ecosystems. Turtles, in particular, are documented to be able to live under harsh environmental conditions and can tolerate significant levels of environmental disturbance. Often the dynamics and concentrations of the contamination event(s) might be unknown, in addition to effects on the organisms within the ecosystem. Estimation of toxicant effects on organisms is particularly relevant in areas such as the Savannah River Site (Aiken, SC), where uranium and nickel (>40,000kg) were deposited over a thirty year period into a holding pond that experienced a spillway breach in 1984, releasing much of this material into a clean area. To develop a methodology for addressing toxicant dynamics in complex environments, 500 hatchling red-eared

sliders (*Trachemys scripta elegans*) were gavaged with nickel citrate at concentrations of 25ppm, 100ppm, 400ppm and a metal-free control on a bi-monthly basis. Turtles were housed in experimental mesocosms with three replicates per treatment level. There is no relationship between nickel concentration and mortality or growth rate (carapace length, plastron length, mass). Sections of marginal and plastron bone, and individual scutes of control, 100ppm, and 400ppm individuals have been analyzed using a Synchrotron x-ray fluorescence (SXRF) microprobe at the National Synchrotron Light Source (Brookhaven National Lab, Upton, NY). A nickel gradient concordant with dosing concentration, and patterns of covariation between nickel and other elements (Cu, Zn, Ca) possibly in relation to dosing and feeding events within these bone and scute sections were observed. By evaluating the toxicant data within a temporal context, there is potential for estimating effects of contamination events on other organisms within the ecosystem and thus estimating ecosystem level effects.

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Symbiotic reproduction in minnows: Initial investigation of relationships among *Hydrophlox*

Members of the cyprinid genus *Notropis* subgenus *Hydrophlox* have long been of interest to ichthyologists due to their spectacular breeding colors and their tendency to spawn in the nests of other minnows. In an attempt to better understand this fascinating group, I am investigating the evolution of nest association within subgenus *Hydrophlox* through a series of field observations and experimental manipulations. Paramount to revealing evolutionary trends is the development of a robust phylogeny, yet no focused, cladistically-based phylogenies have been published for this group. As an initial step in examining nest association within *Hydrophlox*, I have generated a single-gene mtDNA phylogeny for all putative members of the subgenus. ND2 sequence data supports a clade including *N. rubricroceus*, *N. chiliticus*, *N. chlorocephalus*, *N. lutipinnis*, and *N. chrosomus*. However, three species traditionally placed in *Hydrophlox*, *N. baileyi*, *N. leuciodus*, and *N. nubilus*, were not recovered as part of this clade. I compare and contrast these results with observed variation in spawning behavior, reproductive coloration, and morphology. **STOYE**
GENERAL ICHTHYOLOGY

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Dipolar hearing measurements in the Horn Shark, *Heterodontus francisi*

The hearing abilities of elasmobranchs have been measured using sounds broadcasted from an underwater speaker in several different experiments. While these experiments have produced complete audiograms for the species tested, many scientists have questioned whether a monopole stimulus (such as an underwater speaker) is appropriate for measuring hearing and determining what

sounds sharks are attracted to in the field. It has been suggested that a dipole stimulus that mimics the acoustic disturbances caused by prey moving through water would be a more relevant stimulus for measuring shark hearing abilities. A vibrational shaker was used to produce a dipole stimulus for testing the hearing of four horn sharks, *Heterodontus francisi*. Hearing tests were also conducted in the same setup on the same individuals using an underwater speaker to directly compare the dipole stimulus with a monopole stimulus. In both cases, evoked potentials were obtained in response to the stimuli using the auditory brainstem response method and audiograms were produced. The relevance of monopole versus dipole stimuli when referencing the hearing of elasmobranchs and how these relate to their ability to detect sounds from a distance will be examined. **AES GRUBER**

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Amphibian population decline in Honduras

The decline and extinction of amphibian populations is a world-wide phenomena and is considered to be an environmental crises. In the New World, 39% of the amphibian species are threatened with extinction, and so are more than half (52%) of the 685 amphibian species of Mesoamerica. Honduras is no exception to this phenomenon, and of the 120 species of amphibians known to occur in Honduras, at least 48 are thought to have declining populations and four are considered extinct. Habitat destruction is the main cause of these declines. Nonetheless, some amphibian populations are declining in pristine areas. Population declines in Honduras were first noticed at the end of 1980s, but the lack of long term population monitoring data makes it difficult to determine when exactly the declines began and why. In 2003 we started generating data on the relative abundance of several species in natural reserves by using direct counts of individuals, nest counts (in the case of one species), and audio counts along transects. In an attempt to confirm the presence or absence of endemic species, we revisited several important localities where population declines were previously noticed. Important recoveries were noticed in some species that have rather extensive geographic and elevation ranges, whereas some others that are restricted to montane habitats have apparently disappeared. In general, species with restricted geographic ranges in montane habitats have been the most impacted.

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Complex Bayesian and parsimony analyses resolve a taxonomically chaotic phylogeny of New World coralsnakes

Coralsnakes represent an extraordinary radiation of brightly colored venomous

snakes including about 90 species. Despite the medical importance and wide distribution of coral snakes (genera: *Micrurus*, *Micruroides*, *Leptomicrurus*), an inclusive and robust estimate of their relationships is not available. We used DNA sequences from two mitochondrial genes (ND4 and cyt-b), one nuclear gene (Rag-1), and morphological characters to estimate the relationships among all major lineages of New World coral snakes. We present maximum parsimony and Bayesian phylogenetic estimates conducted under complex mixed models of evolution designed to maximize the extraction of phylogenetic signal from our mixed character dataset. Our results suggest a majority of species are in need of critical review, and that the genus-level taxonomy of New World coral snakes conflicts with phylogeny, requiring revision. We also show that previously unexplainable results of venom and antivenom research are reconciled only in light of our new phylogenetic hypothesis for coral snakes. These findings highlight the significant implications of our coral snake phylogenetic work outside the field of phylogenetic systematics.

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Preliminary information on the population genetics of the whale shark (*Rhincodon typus*)

In recent years tagging studies, including satellite transmitters, have increased our knowledge of the migratory behavior of whale sharks. These findings reinforce the perception of a mobile species that can move thousands of kilometers in short time periods. Based on the perception of high vagility, we hypothesized that inter-region or inter-ocean genetic differences for whale shark populations would be slight. Here we use mitochondrial DNA control region sequences to assess the genetic connectedness of whale sharks sampled from different oceans. We found 37 polymorphic sites (including insertions and deletions) resolving 18 haplotypes in complete mtDNA control region sequences from 30 whale sharks (10 from Gulf of Mexico; 7 from Sea of Cortez; 4 from Ningaloo Reef, Western Australia; 4 from Taiwan; 3 from South Africa; and 1 each from Maldives and Philippines). We found no significant genetic subdivision and sharing of haplotypes among ocean basins. Our data are consistent with a single global population. This inference, however, is subject to two caveats; low statistical power associated with small sample sizes, and life history considerations. First, there are marked differences observed among haplotypes, including base substitutions and gaps of 17 to 164 nucleotides, indicating that sufficient variation exists to detect population subdivision, pending larger sample sizes. Second, most samples were collected from whale shark feeding aggregations, where reproductively segregated populations could co-occur. Mixing of cohorts could contribute to the lack of phylogeographic subdivision detected here. More sequence data are being gathered to provide a statistically rigorous analysis of genetic variation among biogeographic regions,

including microsatellite approaches for analysis of fine-scale breeding system.
AES GRUBER

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The *Ulva* connection: Marine algae subsidize gecko populations in coastal Peru

How can terrestrial animals survive in a desert with scant primary productivity? The Peruvian coastal desert is hyper-arid, but faces one of the most productive marine ecosystems, the Peru-Chile cold current. Given the stark difference in productivity between these two adjacent ecosystems, I expected to find strong linkages connecting the terrestrial and marine food web. I investigated how marine resources are incorporated in the diet and influence the distribution of terrestrial consumers. Stomach contents from geckos (*Phyllodactylus angustidigitus*) and carbon and nitrogen isotopic values of geckos and other terrestrial consumers suggest that marine green algae of the genus *Ulva* provide energy and nutrients to the terrestrial food web. Isotopic values suggest that amphipods of the genus *Orchestoidea*, which feed on stranded *Ulva*, make marine resources available to terrestrial consumers by moving between the intertidal and supratidal zones. *Orchestoidea* is the most common prey item in the stomachs of geckos. The spatial distribution of geckos indicates that they depend on marine resources. Geckos are 25 times more abundant between 0 and 9 m away from shore than they are between 50 and 59 m away from shore. This study describes a unique community found at the juxtaposition of one of the richest ocean currents and one of the driest deserts in the world. It shows that it is not possible to understand the structure and dynamics of the terrestrial food web without including the effects of marine energy and nutrients. **STOYE ECOLOGY & ETHOLOGY**

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Phylogenetic information from the centrarchid fossil record

An osteological study was made on some of the earliest known Centrarchidae in order to learn more about the plesiomorphic character states within the family. These fossils are late Eocene in age and come from a drainage flowing east over the ancestral Great Plains toward the Mississippi Embayment. Preservation in freshwater limestone deposits indicate clear, well oxygenated water, high in pH, and most likely with abundant aquatic vegetation. The ancient fossil site was situated on a slightly elevated land surface that was stable over a long period of time when stream gradients were low. The fossils do not fit with any of the Recent genera and could possibly represent a stem form. Twelve characters were examined and polarities determined. Plesiomorphic states included low number of vertebrae, small body size, dorsal fin with a lower number of spines graded in length, and an anal fin with 3 anal spines (3 seem to be found in basal members

of the major centrarchid clades). A number of the skeletal features call attention to the primitive Recent genus *Enneacanthus* but there are some obvious differences associated with habitat.

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Population genetics of the Tope Shark (*Galeorhinus galeus*) in response to California fishery pressures

The Tope Shark (*Galeorhinus galeus*) has been the subject of intense overfishing over the last 74 years (Ripley 1946, FAO.org). Millions of sharks were harvested during the 1940s primarily for their vitamin A rich livers (Ripley 1946, Leet et al. 2001). This intense exploitation collapsed breeding areas within the San Francisco and Tomales bays (Leet et al. 2001). Currently all sharks face a new global threat, that of shark finning. Unfortunately, only well-qualified estimations exist on how many sharks inhabit the world's oceans. Without exact population data, the impact of overfishing on shark species can only be assumed. Because empirical estimation of true population sizes of pelagic shark species is unrealistic, a method of determining shark population health is sorely needed. The tope shark provides an excellent model because the species was historically overfished (Leet et al 2001). By analyzing and comparing the mtDNA of present day tope sharks with the mtDNA of specimens preserved prior to 1940, evidence of inbreeding and the possible existence of a population bottleneck may be established.

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The effects of body size and relatedness on male reproductive success in an aggregate breeding amphibian (*Ambystoma maculatum*)

The outcome of sexual selection on males may depend on female mate choice and male-male competition, as well as post-copulatory processes such as sperm competition and cryptic female choice. We studied the outcome of sexual selection in the spotted salamander (*Ambystoma maculatum*), specifically examining the role of body size and relatedness to potential mates on male reproductive success. Using controlled mating experiments in the field, we gave females access to three males of different sizes. We then used seven microsatellite loci to determine paternity in the resulting larvae and to estimate two relatedness measures between females and their mates. We also calculated the average *md2*, a measure of genomic divergence, across all larvae and compared it to values predicted by simulations under the assumptions of random mating and random mating with reproductive skew. Male body size did not affect reproductive success, suggesting a limited role for male-male competition in sexual selection in this system. One relatedness measure significantly influenced male success; males that were more closely related to females sired more offspring. Females

seemed to avoid fertilizing their eggs with sperm from too distantly related males. However, the relatedness of the males available to a female did not significantly influence the proportion of larvae sired by stored sperm. The observed outbreeding avoidance resulted in lower genomic divergence in offspring than predicted by chance. Our results suggest that genetic compatibility may be a more important determinant of reproductive success than body size in this species, and the evolution of aggregate breeding may facilitate an individual's search for compatible mates by bringing many individuals together.

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Mating systems of the bonnethead and scalloped hammerhead sharks in the southeast United States, as revealed by microsatellite DNA profiling

Just as DNA-profiling has revolutionized our understanding of the reproductive biology of many animal groups, this technology has begun to provide significant new insights into the mating practices and parentage of free-living sharks. Genetic profiling of two shark species (nurse [*Ginglymostoma cirratum*] and lemon [*Negaprion brevirostris*]) have revealed almost ubiquitous multiple paternity of litters within the sampled study populations. In contrast, our recent studies have revealed that female bonnethead sharks (*Sphyrna tiburo*; Family Sphyrnidae [hammerhead sharks]) demonstrate a relatively low frequency of multiple paternity within a given reproductive cycle (<20% of 22 litters directly tested by microsatellite genotyping). Collectively, these studies indicate diversity in the mating systems of sharks, raising interesting questions as to what factors drive the evolution of female promiscuity and multiple paternity in these ancient fishes. To further explore this issue, we have expanded our analysis of parentage in *S. tiburo* to include a total of 70 litters (>650 embryos), originating from breeding grounds along the Gulf coast of Florida and South Carolina. Despite an increase in sample size, multiple paternity remained low overall and we tested the hypothesis that it is more common in larger females. We also genotyped 20 litters (>400 embryos) of scalloped hammerheads (*S. lewini*), a larger, ecologically dissimilar congener of *S. tiburo*. Although we document the first records of multiple paternity in *S. lewini*, the mating system of this species appears to be more akin to that of *S. tiburo* than it is to that of *N. brevirostris* and *G. cirratum*.

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Distribution of elasmobranchs in the Brazilian Amazon River floodplain

The Amazon River floodplain is associated with white water rivers and presents seasonal changes that are closely linked to the hydrologic cycle. The information available on the elasmobranch species and respective distribution in the Solimões-Amazonas River system was very limited. An expedition was organized in September and October 2003 to collect data on the distribution of elasmobranchs, among other species groups. Twenty-six points of sampling were spread along over 3,000 km in the Brazilian portion of the Amazon River floodplain. Daily bottom long-line fisheries (captures), direct observation of specimens (registers) and interviews (reports) were used to provide evidence on the local elasmobranch species. Frequency of occurrence and biomass were calculated for each species. Water parameters were also noted. The results correspond to a unique specific study on the diversity of elasmobranchs present in this aquatic system. Information related to three elasmobranch families were obtained, namely: Pristidae, Carcharhinidae and Potamotrygonidae. The species that presented a wider distribution were: *Paratrygon aiereba*, *Plesiotrygon iwamae*, *Potamotrygon motoro*, *Pristis perotteti* and *Carcharhinus leucas*. Some potamotrygonid species were only observed in certain areas. It is suggested that some of the tributary rivers directly influence the Amazon River system by creating a water transition area close to their mouths that consequently may affect distribution patterns. The results indicated the presence of four linked but distinct biogeographical regions. A fifth region could be considered the estuarine area with the seasonal influence of higher salinity levels and the register of occurrence of dasyatids. Biological data on species distribution along the Amazon River floodplain is essential for adequate conservation planning in this dynamic and threatened river system. (Supported by Pró-Várzea - IBAMA-PNUD BRA/00/008 / MPEG / FADESP and CAPES). **AES GRUBER**

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Paratrygon aiereba: A multi-species complex (Chondrichthyes: Potamotrygonidae)

Neotropical freshwater stingrays belong to a single family that is considered

monophyletic by several authors. The Potamotrygonidae family is comprised of three valid genera, namely: *Plesiотrygon*, *Potamotrygon* and *Paratrygon*. A fourth genus is currently under description. Two of these genera have been considered monotypic and are represented by the species *Plesiотrygon iwamae* and *Paratrygon aiereba*. On the other hand, *Potamotrygon* includes 18 described species but there are approximately 8 other species being described or under study. The recent increment in collecting and research activities carried out with potamotrygonids has brought up clear evidence that *Paratrygon aiereba* corresponds to a multi-species complex and that *Paratrygon* is not a monotypic genus. The preliminary analyses indicate that the *Paratrygon* genus comprises at least two or possibly three distinct species. It is likely that future sampling in some Amazonian river drainages still might alter this number. These species are distinguished by external and internal morphological characteristics, as well as morphometric differences. Intra-specific polychromatism was also evidenced, as in other species belonging to this family. The ecological aspects associated with river drainages seem to play an important role in these species geographical distribution. *Paratrygon thayeri* (Garman, 1913), currently treated as a synonym of *Paratrygon aiereba*, might be revalidated, pending on a more detailed study of morphometric and distributional data. Meanwhile, studies are under way and more specimens are being collected to elucidate this multi-species complex and to provide the required descriptions and redescriptions. (Supported by CNPq and CAPES grants). **AES CARRIER**

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A phylogenomic perspective on the relationships among basal actinopterygians

We present a multilocus phylogenetic analysis to assess relationships among the living basal actinopterygian lineages (bichirs, gars, bowfin, sturgeons and teleosts) and to test the fish genome duplication hypothesis. Using all available data in Genbank and the completed genomic databases (zebrafish, fugu and *Tetraodon*) plus our own sequencing effort (RAG-1 exon 3, for 1473 bp) we compiled and analyzed 10 datasets of nuclear protein-coding genes and one dataset of mitochondrial ribosomal genes (12S and 16S) that are shared by the core taxa (bichir, gars, bowfin, sturgeons, zebrafish and two puffers) plus selected out-groups. More than 12,000 bp of nucleotide sequence were collected for each taxon. We performed a wide array of analysis (separated and simultaneous analysis of the data partitions) using different phylogenetic methods for both nucleotide and amino acid sequences to gauge the robustness of the resulting phylogenetic hypothesis. We also conducted tests for eight relevant alternative hypotheses proposed from either morphological or molecular evidence depicting the relationships among basal actinopterygian lineages. A traditional clade, the Holostei comprising gars and bowfin, was supported in 61 out of 91 individual analyses and in the total evidence tree. Results from topology tests reject 7 alternative hypotheses but favour a tree topology initially proposed by G. Nelson (1969) based on comparative anatomy of gill arches. In addition, three out of ten datasets of nuclear protein-coding genes support the fish specific genome duplication hypothesis.

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Reproductive ecology of the Argentine Boa Constrictor and implications for conservation

Habitat use analysis is a basic tool for the conservation and management of wild populations. Reproduction condition often has obvious effects on habitat use. Quantifying the changes in the use of resources associated with reproduction can offer an insight into the selective forces acting on organisms in this critical phase of life history. The Argentine territory supports the world's largest and southernmost population of *Boa constrictor occidentalis*, a threatened species. The purpose of our study was to compare use of habitat and thermoregulation in gravid and non-gravid individuals during the dry season in the Argentinean xerophytic forest. Body temperatures were recorded from gravid and non-gravid adult free-ranging radiotagged individual boas using temperature-sensitive telemetry. Habitat usage data were collected during the same time period and the area used by gravid and non-gravid individuals was compared. Reproductive individual females have been observed in habitats different from those frequented by males and non reproductive females. Gravid individuals were found to be more precise thermoregulators than non-gravid specimens. In addition, the area used by gravid individuals was found to be significantly less than the area of habitat used by non-gravid individuals. Habitat choice made by reproductive females would allow them to choose adequate places to bask in the sun and get higher and optimum temperatures for embryo development. Since reproduction in boas relies upon specific environmental characteristics, embryo development would be an excellent indicator of habitat availability and health. Viability of this species depends upon a thorough and complete understanding of thermoregulation in gravid individuals. The endangered status of Argentine boa constrictor requires a comprehensive understanding of their ecology, and thermoregulation constitutes an essential aid to this understanding. The long-term monitoring of wild populations should be a priority for the development of conservation and management plans on behalf of this boid.

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Declining glassfrogs: Diversity and conservation status of the Centrolenidae from Ecuador

The global conservation status of the family Centrolenidae is alarming. This Neotropical family currently includes 138 described species and almost half of them (60) are considered under some IUCN category of threat. Further forty-nine species are categorized as Data Deficient. Thirty-two species of Glassfrogs have been reported from Ecuador, but recent studies estimate that the diversity of

Centrolenid frogs in Ecuador is at least 57 species. However, a shocking 55% of the described species from Ecuador are threatened, five species are considered Data Deficient; and most of the undescribed species are known from very few specimens and small distribution areas. The highest diversity of Glassfrogs in Ecuador occurs at the Low Montane and Cloud forests on the Pacific and Amazonian versants, unfortunately almost every species from these areas are threatened by extinction. Recent surveys into areas previously known by its high Centrolenid diversity have failed to find most species; 15 Ecuadorian species have not been seen in the last twenty years, and 23 species are known from less than 5 localities. Data indicate that several species of Glassfrogs have catastrophically declined. Several causes could influence or synergistically act to cause the declines including diseases (eg. chytridiomycosis), local or global climate change, introduced alien species (eg. trouts), habitat modification / degradation or loss, environmental pollution, or natural disasters.

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Feeding kinematics and functional morphology of the feeding apparatus of the hagfish (Myxinidae)

Hagfish are basal craniates that lack jaws. Instead of jaws, hagfish possess a cartilaginous dental plate with a series of cusps that resemble grasping dentition. A series of ventrally situated cartilaginous elements (the basal plate) support the dental plate and feeding muscles. During feeding, a network of protractor and retractor muscles pull on the dental plate resulting in a protraction-retraction movement. The protractor and retractor muscles behave in a manner analogous to gnathostome jaw abductor and jaw adductor muscles, respectively. Hagfish (*Myxine glutinosa* and *Eptatretus stoutii*) were housed in a glass aquarium with circulating ASW at 10°C. Feeding kinematics were recorded with a digital camera (30 fps) and analyzed with Adobe Premiere 6.0 and Image J. We measured bite cycle times and compared the resulting values with those of nine elasmobranch species. Bite cycle times of hagfish were longer than the previously recorded bite cycles of nine elasmobranch species. Bite cycle times re-scaled to body length of the hagfish were shorter than eight of the nine re-scaled elasmobranch bite cycles. The longer bite cycle times recorded from hagfish indicate a disadvantage of lacking jaws.

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Genetic divergence and population genetic structure in the sister species pair *Ammocrypta bifascia* and *A. beanii*, with comments on a possible new species

Ammocrypta beanii, the naked sand darter, and *A. bifascia*, the Florida sand darter, speciated from a common ancestor approximately 2 - 4 million years ago, and have been thought to compose a sister species pair. They occupy adjacent, but

nonoverlapping ranges in freshwater streams of the Gulf Coast of the United States. Using AFLP fingerprints from individuals from a total of 16 populations representing multiple drainages for each species, I calculate genetic divergence between the species and also compare population genetic structure of the species using Wrights Fst. Results show that the *A. beanii* populations within the Mobile Bay (MOB) drainage likely represent a new species (genetic distance 0.40 between MOB and other *A. beanii* vs. 0.12 between populations within these groups). Genetic divergence (Reynolds distance) between *A. beanii* without MOB and *A. bifascia* is 0.64. Most of the variation within these species lies within populations, rather than among drainages, and population structure of these two species is extremely similar (*A. beanii* without MOB Fst = 0.114; *A. bifascia* Fst = 0.116).

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Behavioral comparisons of two sympatric clownfish species (*Amphiprion clarkii* and *A. perideraion*) as symbionts of the anemone *Heteractis crispa*

The symbiosis between resident clownfish and their host anemones has been well-characterized from the fish' point of view. However, little attention has been directed towards the benefits the anemone may receive from the fish, nor has there been a focus on behavioral comparisons of different clownfish species which partner with a given species of anemone. As part of a larger investigation exploring the potential nutrient transfer between resident clownfish and host anemones, we made behavioral comparisons between two sympatric clownfish species (*Amphiprion clarkii* and *A. perideraion*) symbiotic with the anemone *Heteractis crispa* to explore whether one fish species might be a "better" symbiont to the anemone than the other species. If resident clownfish provide nutrients to their host anemone while in close contact with anemone tentacles, the fish species that maintains the closest contact with its host may be a better provider. We observed individual females of each clownfish species for 10-min intervals from 0600-1800 to characterize 1) the amount of time the females spent within 25 cm of their anemone, 2) the duration of each visit to an anemone, 3) the number of anemones a female regularly visited, and 4) the average number of subordinate fishes within each anemone visited. Female *A. clarkii* spent significantly less time (1.06 ± 0.14 min) within 25 cm of their host anemone than did female *A. perideraion* (5.2 ± 0.8 min). The average duration of any one of a female's visit to one of her anemones was 0.4 ± 0.1 min for *A. clarkii* and 3.2 ± 0.8 min for *A. perideraion*. Female *A. clarkii* visited 4.3 ± 1.4 anemones during a 10-min interval; female *A. perideraion* visited 1.9 ± 1.0 anemones. The number of subordinate fish residing in each anemone also varied significantly; 4.3 ± 1.4 subordinate fish were found within *A. clarkii* anemones and 1.9 ± 1.0 subordinate fish were found within *A. perideraion* anemones. Field studies where both clownfish species are fed pellets marked with ^{15}N are currently in progress; the goal of these studies is to determine whether *A. perideraion*, which appears to be more closely associated with its host anemone, translocates significantly more nitrogen to its host than does *A. clarkii*.

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Use of fallen trees for spawning by the spotfin shiner (*Cyprinella spiloptera*)
in the Upper Mississippi River

The spotfin shiner is a crevice spawner that inserts its eggs into large cracks in the substrate. In small streams, it may use crevices among rocks, but it also occurs in large rivers where the substrate is primarily sand. Previous observations have suggested the possibility that spotfin shiners use the bark of fallen trees for spawning in large rivers. The purpose of this study was to investigate the association of spotfin shiners with woody snags in a channel border habitat of the Upper Mississippi River. Three fallen trees in Pool 6 were sampled by electrofishing on three dates during July, August, and October. Spotfin shiners in breeding condition were the most abundant fish around each snag in July, the peak of the breeding season, but the mean catch declined in August and October. Relative numbers of spotfin shiners and other fish varied significantly among the sample periods. A decline in the use of snags after the breeding season is consistent with the results of a previous study in Pool 6, in which spotfin shiners were not collected close to woody snags during the fall. This suggests that during the summer woody snags are used for spawning rather than for cover.

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Hatch or wait II: Another dilemma in reptilian incubation.

Animals often form groups to reduce the risk of predation through the per capita dilution of their individual predation risks. In particular, synchrony in the timing of births may have evolved as a predator-avoidance strategy as it dilutes the risk of predation upon vulnerable neonates. Hatching synchrony may occur via more advanced embryos "waiting" for less developed clutch mates, or by less advanced embryos "catching up." For hatchlings of turtle species that obligately over-winter in the nest, the drive to hatch synchronously should be reduced, as emergence does not occur until the following spring. Hatching synchrony is even less likely if the mechanism for "catching up" is to shorten developmental times, causing a developmental cost to less advanced individuals. To test this hypothesis, we induced developmental asynchrony by dividing clutches of the painted turtle, *Chrysemys picta*, into 26°C and 30°C incubation treatments for seven days before clutch-mates were reunited. We assessed degree of development by noting the time required for each turtle to right itself when placed on its carapace. Synchronous hatching did not occur, but less advanced eggs always hatched earlier than control eggs. Turtles from eggs that hatched early experienced a developmental cost as those neonates took significantly longer to right themselves. We conclude that the less advanced embryos within a clutch hatch prematurely to ensure synchrony of hatching. The occurrence of this characteristic in a species that should have no drive to hatch synchronously contradicts current explanations that this behavior in animals evolved as a means

to reduce predation risk. Instead, we propose that hatching first may be important in securing the optimal thermal locations within a nest before overwintering in this species, or simply that synchronous hatching is a primitive trait ubiquitous among turtles. **SSAR SEIBERT ECOLOGY**

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Storms, growth and egg size in riverine neotropical cichlids

Egg size is the result of a spectrum of selection pressures operating on parents, the eggs and the resulting fry. The parent, for example, faces a tradeoff between egg size and number while the size of an egg influences the time it takes to hatch and the size of the hatchling. Different species resolve these tradeoffs differently to produce eggs of different sizes. This produces a range of egg sizes within a given environment and constrains species to spawn in particular locations within the riverine environment. Storms, which produce large changes in water level, velocity and temperature likely have dramatic influences on the survivorship of eggs (and fry). The effects of these storms will likely vary with the size of the offspring. By utilizing long-term in-situ temperature recordings, we examine the relationship between periodicity of storm events, egg size, growth rate and spawning site selection of cichlids in a neotropical fast-flowing river.

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Does morphological disparity evolve at the same rate in two lineages of centrarchid fishes?

Evolutionary lineages differ with regard to the variety of forms they exhibit. I investigated whether comparisons of morphological diversity can be used to identify differences in ecological diversity in two sister clades of centrarchid fishes. Species in the *Lepomis* clade (sunfishes) feed on a wider range of prey items than species in the *Micropterus* clade (black basses), and I asked whether this difference in diet diversity is reflected in diversity of morphological characters of the feeding apparatus. I quantified morphological disparity as within-clade variance on principal components and found that *Lepomis* exhibits 4.4 and 7.4 times more variance than *Micropterus* on the first two principal components. However, lineages are expected to diversify morphologically and ecologically given enough time, and this pattern could have arisen due to differences in the amount of time each clade has had to accumulate variance. Despite being sister groups, the age of the most recent common ancestor of *Lepomis* is approximately 14.6 million years ago (mya) and its lineages have a total length of 86.4 million years (My) while the age of the most recent common ancestor of *Micropterus* is only about 8.4 mya and it has a total branch length of 42.9 My. I used the Brownian motion model of character evolution to test the hypothesis that time of independent evolution of each clade's lineages accounts

for differences in morphological disparity. This analysis involved testing whether rates of morphological evolution are equivalent in these clades, and I determined that the first two principal components evolve 4.4 and 7.7 times faster in *Lepomis*. Thus, time and phylogeny do not account for the differences in morphological disparity observed in *Lepomis* and *Micropterus*, and other diversity-promoting mechanisms should be investigated.

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Phylogeny of Recent billfishes (Xiphoidei)

Molecular phylogenies recover separate Xiphoidei and Scombroidei clades. Billfishes are morphologically and genetically distinct enough to be placed in a separate suborder. Two families are recognized within Xiphoidei: Xiphiidae (swordfish, *Xiphias gladius* and Istiophoridae, 3 genera, *Istiophorus* (sailfish), *Makaira* (marlins), and *Tetrapturus* (spearfishes, white and striped marlins). Maximum parsimony analysis of the molecular data shows a very different picture of relationships. *Makaira* does not appear to be monophyletic: blue marlin cluster with sailfish and black marlin cluster with spearfishes but there is little morphological support for this conclusion. Accepting the molecular phylogeny gives 2 possible classifications: 1) 2 genera: blue marlin + sailfish (as *Istiophorus*) and all the rest (as *Tetrapturus*); or, 2) 5 genera: blue marlin (*Makaira*), sailfish (*Istiophorus*), black marlin (*Istiompax*), striped and white marlin (*Kajikia*), and the 4 spearfishes (*Tetrapturus*). There is no genetic evidence to support recognition of Atlantic and Indo-Pacific populations of sailfish or blue marlin as separate species.

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Lizards and termites revisited

We evaluate the hypothesis, originally proposed for arid Australia, that abundant and diverse termite assemblages can promote lizard radiation, based on a reappraisal of published data and on new data from the Cerrado biome in central Brazil. We found a positive correlation between termite and lizard richness in the Cerrado area. However, termite abundance and diversity cannot actively drive lizard speciation, but can be important in maintaining lizard diversity. The Cerrado shares with arid Australia a rich and abundant termite fauna, but local Cerrado lizard assemblages are relatively impoverished. We suggest that differences in lizard diversity between Cerrado and arid Australia may be explained by a combination of variations in area and latitude controlling speciation rates and present-day ecological factors moderating extinction rates.

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Diet of the Atlantic Cownose Ray *Rhinoptera bonasus* in Charlotte Harbor, Florida, USA

Cownose rays are benthic, suction feeders whose foraging activities have been implicated in severe damage to commercial shellfish industries and seagrass habitat. With jaws highly modified for durophagy, it has been assumed that they are crushing specialists, feeding primarily upon hard molluscan prey. Stomach contents from cownose rays caught within the Charlotte Harbor estuary between July 2003 and July 2004 were analyzed using the index of relative importance (IRI). A total of 92,576 prey items from 38 families fell into 9 distinctive groups: bivalves, gastropods, crustaceans, brachiopods, chordates, echinoderms, nematodes, polychaetes, and detritus. Adult and juvenile diets showed significant overlap (Schoener's index = 0.69). Crustaceans, polychaetes, and bivalves were the dominant groups present over all stomachs examined. Crustaceans (%IRI = 56.85) and polychaetes (%IRI = 25.90) were the most important prey groups, with cumaceans (*Cyclaspis* sp. and *Oxyrinchus smithii*) accounting for the majority (94%) of crustaceans and *Pectinaria gouldii* representing the bulk (70%) of the polychaetes. Bivalves were the least abundant of the three dominant groups (% IRI = 12.93). *Cyclaspis* sp., *O. smithii* and *P. gouldii* are prevalent benthic invertebrates within Charlotte Harbor and can occur in extremely high densities. All cumaceans and polychaetes within ray stomachs were intact, indicating capture through suction feeding. All larger, hard prey (bivalves, echinoderms, and brachiopods) showed evidence of crushing (fractured and broken shells). Although currently believed to be a hard prey specialist, these results suggest the cownose ray may behave as an opportunistic generalist, modifying feeding behavior to consume any readily available prey.

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Tracking the cownose ray *Rhinoptera bonasus* within a southwest Florida estuary: Evidence for residence?

The Atlantic cownose ray *Rhinoptera bonasus* is present within the Charlotte Harbor estuary throughout the year. Although believed to be highly migratory, transient residents of coastal inshore waters, minimal quantitative data exist regarding their distribution, movement patterns, or abundance. Between July 2003 and April 2005, 27 cownose rays (18 adults and 9 juveniles) were tagged and tracked within Pine Island Sound and the Caloosahatchee River using passive acoustic telemetry. Minimum convex polygons (MCP) and kernel utilization distributions (KUD) were calculated to demonstrate the extent of an animal's home range and core areas of use. Animals were monitored within the study

area for periods of 1-223 days (mean = 42 days). Nine individuals were observed moving regularly between Pine Island Sound and the Caloosahatchee River, maintaining activities over a wide range of salinities (5.0 -30.0 ppt) and habitat. Rays within the Caloosahatchee River were typically present for longer continuous periods, while rays tracked in Pine Island Sound tended to move in and out of the study area more frequently. Daily MCPs ranged between 0.01 and 25.8 km². As highly mobile, pelagic swimmers capable of traversing large distances, these data show that cownose rays may also remain within very small areas for extended periods. Total core areas of use (50% KUD) were located over sand or mud bottom for 23 of the 27 tracked rays. Only 4 rays had core areas that significantly overlapped seagrass habitat, contrasting with existing suspicion that they heavily utilize grass beds. These tracking results provide insight to *R. bonasus* use of a south Florida estuary and allow predictions regarding the impact of this species in similar environments. **AES GRUBER**

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Comparing alternative models for multivariate morphological data: An example with the Prairie Rattlesnake (*Crotalus viridis viridis*)

There has been a recent surge in the use of geometric morphometric (GM) methods to describe organismal shape variation. In order to make proper ecological inferences, one must choose the best ecological model from several alternative models of morphological variation. While model selection methods have been well-developed for univariate data, their use with multivariate data is less explored. Here we introduce a method for distinguishing among alternative models for GM shape data. We use a multivariate generalization of Akaike's information criterion (*m*AIC) and Wilks' likelihood ratio test to compare the determinants of covariance matrices from candidate models of shape variation. We illustrate the effectiveness of this approach with simulated examples and apply the same method to real data collected from populations of the Prairie Rattlesnake (*Crotalus viridis viridis*). Using model comparisons, we were able to statistically compare the strength of the relative contributions of sexual dimorphism and geographic variation in the shape variation of *C. v. viridis* for populations in North and South Dakota. Whereas multivariate analysis of variance indicated significant sexual dimorphism in this species, comparison of models with and without sexual dimorphism terms showed that they did not statistically differ, indicating that the contribution of sexual dimorphism to overall shape variation was minimal. We conclude that the use of model selection methods can greatly improve inferences made for models of multivariate data.

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Seasonal variation in the sonic muscles of male and female Atlantic croaker, *Micropogonias undulatus*

We examined variability in the sonic muscles of male and female Atlantic croaker *Micropogonias undulatus* with the approach of the spawning season. Sonic muscle mass and thickness increases in the weakfish *Cynoscion regalis* prior to the spawning season in response to rising androgen titers and as a result of increasing fiber cross-sectional area. In the croaker, unlike the weakfish, both male and female croaker bear sonic muscles and the muscle is used both for courtship and fright-response sound production. We hypothesized that since only the male croaker produces courtship calls, the sonic muscles of the male would increase in size with the onset of the reproductive season, while those of females might decrease in size, reflecting a relative decrease in muscle use. Male sonic muscle mass and length increased significantly with the approach of the spawning season, while female sonic muscle thickness, mass and length decreased significantly. When regressed across gonad mass, sonic muscle mass varied significantly, increasing in males and decreasing in females. Histological examination of sonic muscle fibers revealed that fiber cross-sectional area (CSA) increased significantly in males as the spawning season approached. Though a decreasing trend was noted in female fiber CSA, this seasonal variation was not statistically significant. In males, a significant correlation existed between increasing sonic muscle mass and fiber CSA. Variation in fiber CSA was primarily attributed to changes in myofibrillar area. While some variation was noted in sarcoplasmic area, they were minor compared to the substantial pre-spawning hypertrophy noted previously in weakfish. Increasing sonic muscle mass in male croaker is likely tied to increasing androgen titers, as sound production is used during courtship; however, the decrease in female sonic muscle size is interesting and might result from increasing estradiol levels, decreased use or a combination of the two.

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Investigations into the activity patterns and space use of juvenile sandbar sharks, *Carcharhinus plumbeus*, in the Eastern Shore of Virginia summer nursery area

The sandbar shark is the most abundant large coastal shark found in the waters off the East Coast of the United States and is the principal species caught in the commercial shark fishery off the Atlantic coast. Examining the habitat use and activity patterns of juvenile sandbar sharks of this population while they occupy summer nursery areas is an important research need for current and future management efforts. During the summer of 2003, 15 stationary acoustic receivers

were anchored in Wachapreague Inlet, Virginia and 27 sandbar sharks were surgically implanted with coded acoustic transmitters. Each time a receiver detected a transmitter it recorded the date, time, and identification of that transmitter. Data was downloaded every week from the receivers throughout the summer from July 7th when the first shark was captured and implanted with a transmitter to the last shark's departure from the area on September 30th. During the summer of 2004, the array was expanded to include 21 receivers and an additional 37 sharks were implanted with transmitters. In addition, 10 sharks implanted with transmitters in 2003 returned to the area and were detected by the array in 2004 and were tracked for various periods of time. During 2004, the receivers were placed in the field June 2nd and remained in place until the last shark's departure on October 4th. Preliminary data on the activity patterns and habitat use of juvenile sandbar sharks in this summer nursery area will be presented. **AES GRUBER**

COOPER, W. JAMES

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The evolution of feeding biomechanics in damselfishes

The damselfishes (Perciformes; Pomacentridae) comprise one of the dominant groups of fishes on all coral reefs and are a major component of the trophic ecology within these systems. This study examined the evolution of damselfish feeding mechanisms by combining morphological, biomechanical and phylogenetic analyses of all damselfish genera. Digital images of dissected and cleared and stained specimens were used to generate coordinate data for the location of morphological landmarks important for feeding. Thin plate spline, principal components, and procrustes superimposition techniques were then used to determine relative differences in the location of these landmarks among pomacentrid species and to describe the distribution of their skulls in shape space. Using biomechanical software, these same coordinates were also used to make functional predictions of damselfish trophic capabilities (e.g. maximum jaw protrusion, maximum gape, the mechanical advantage employed during biting). Preliminary kinematic analyses of pomacentrid feeding strikes support the accuracy of these predictions. Both the morphological and functional data were then plotted on pomacentrid phylogenies generated using Bayesian and maximum parsimony techniques. These phylogenetic hypotheses are based on analyses of DNA sequences from 2 nuclear genes (RAG2 and Bmp-4) and 2 mitochondrial genes (12S and 16S rRNA), totaling approximately 3,000 base pairs and including data from over 100 species in all 29 damselfish genera. This comprehensive approach to examining trophic evolution has yielded detailed information about the diversification of feeding mechanisms within the Pomacentridae. The more stalwart skulls of the primarily benthic feeding, basal damselfishes have given rise to more gracile forms. There is also a general trend away from ancestors that are associated with rocky reefs towards the habitation of coral reefs. Such evolutionary transitions are associated with increased planktivory, a trophic habit that has evolved multiple times from multiple morphological starting points within this lineage. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

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Ecomorphology of shark electroreceptors

Sharks are found in nearly every marine habitat and possess numerous adaptations that enable them to survive in a multitude of ecosystems. I examined whether morphological differences in the electrosensory system of sharks correlate with their environment and ecology. By quantifying the number, density, and distribution of electrosensory pores for a large number of species, I have been able to elucidate trends in the ecomorphology of shark electroreceptors. This study consisted of two separate analyses. I examined the electrosensory system of species from the same family that inhabit different environments as well as species from different families that inhabit the same environment. This was done to determine whether similarities in the electrosensory system result from phylogenetic constraint or evolutionary convergence from a common environment. Pelagic species were found to possess relatively few electrosensory pores (450-900) with the majority of species having over 60% of the pores on the ventral surface of the head. Deepwater species have electrosensory pore counts that range from 250-1150 with 38-59% of the pores located on the ventral surface of the head. Shallow coastal species exhibit wide variation in pore counts ranging from 430-3000 electrosensory pores. The distribution of pores ranges from 43-66% on the ventral surface. Several species were examined from the order Carcharhiniformes. This taxa has greater pore counts overall, with most species possessing over 1400 electrosensory pores. The carcharhinids typically have an even distribution of electrosensory pores on the dorsal and ventral surfaces. The results reveal that both phylogenetic constraint and convergence from a common environment have acted in concert in the development of the elasmobranch electrosensory system. **AES GRUBER**

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Bayesian hierarchical meta-analysis of elasmobranch age and growth data

Describing the relationship between age and growth is central to understanding fish population dynamics and conducting stock assessments. Growth curves for elasmobranchs are often unavailable for populations of a given species or for related species and there is often uncertainty surrounding parameter values, all of which ultimately hinder progress in assessment and conservation of this group of fishes. By combining data sets of related populations or species, Bayesian hierarchical analysis can be used to predict parameter values for populations or species for which no age and growth data are available. This approach takes into account both model form (the ubiquitous von Bertalanffy growth function in our case) and parameter uncertainties. Here, we explore the use of this methodology for elasmobranch age and growth data by considering several case studies involving species of sharks for which age and growth data from several populations or studies are available, and one case study for several related species of carcharhinid sharks. We then predict von Bertalanffy

parameters for populations/species for which no data exist while taking account of natural and methodological variability. In this application of a Bayesian hierarchical analysis, which was previously applied to stock-recruit data for salmon, we first assume that the von Bertalanffy parameters of the individual growth curves for each population or species are related and assigned a prior probability distribution. We then use the relationships between the von Bertalanffy parameters of the individual growth curves to predict parameter values for populations or species for which no data exist.

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Community structure of demersal ichthyofauna sampled by bottom longlines in two areas along the Mid-Atlantic Ridge: A summary of the data collected on the M/S Loran during the MAR-ECO project

As part of the 2004 MAR-ECO survey of the Mid-Atlantic Ridge, the commercial longliner M/S *Loran* caught a total of 8595 fishes, representing 38 species and 17 families. Sampling was conducted with 58 longline sets (36 bottom longlines and 22 vertical longlines) within two areas along the Mid-Atlantic Ridge. The southern area was north of the Azores Islands and the northern area was along the Charlie Gibbs Fracture Zone. The longlines were set in depths ranging from 400 to 4300 m, with the shallowest stations sampled by vertical longlines. Average fish weight was lower in the northern than in the southern area, although CPUE was higher in the north. No differences in average weight or CPUE were observed with respect to depth, although species dominance changed with depth. Overall, chondrichthyans accounted for approximately 60% of the total weight of fishes captured. This was mainly due to the dominance of *Etmopterus princeps* in the shallower stations. General trends of species distribution by depth and range will be presented, along with indices of diversity with respect to depth and geography.

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Shark bycatch in Alaskan federal waters

Three shark species commonly occur in Alaskan waters: Pacific sleeper shark, *Somnius pacificus*, spiny dogfish, *Squalus acanthias*, and salmon shark, *Lamna*

ditropis. Information on the distribution, stock structure, and life history characteristics of these species is extremely limited. There are currently no directed commercial fisheries for sharks in Alaskan federal waters, but sharks are captured incidentally as bycatch in federally managed commercial fisheries for other species and some shark bycatch is now being retained. Limited available data from the commercial fishery observer program and from fishery independent surveys indicate that bycatch of sharks in Alaskan federal waters is low (< 3%) relative to targeted catch. However, shark bycatch is considered a nuisance, and there is a perception by some that shark numbers are increasing in Alaskan waters. As a consequence there is increasing pressure to open directed commercial fisheries targeting some shark species, particularly spiny dogfish. Establishing sustainable catch limits under the current federal management regime requires either a catch history, or a reliable point estimate of biomass combined with a natural mortality estimate; none of these exist for shark species in Alaskan waters. As a consequence, alternative management strategies need to be developed and implemented for these potentially vulnerable species if targeted fisheries are permitted.

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Pesticides and amphibian declines in the Sierra Nevada Mountains, California

Previous studies have shown that pesticides from the Central Valley of California enter the Sierra Nevada ecosystem through aerial deposition in snow and rain, and that surface concentrations of certain pesticides are within an order of magnitude of the 96hr LC50 of amphibians. *Pseudacris regilla* hatchlings were translocated (with controls in each park) and placed in cages in sites located in Lassen, Yosemite, and Sequoia National Parks. Tadpoles were sampled at 28 days and at metamorphosis. Preliminary results show 1) significant difference ($p=0.04$) in DNA damage in metamorphs between Lassen (reference site) and the other two parks; 2) greater survivorship to metamorphosis at Lassen; 3) hindlimb deformities (brachymelia) in 25% of animals sampled at Yosemite and 5% at the other two parks; and 4) residues of various pesticides such as chlorpyrifos, endosulfan, and malathion in frog tissues. Discovery of detrimental effects in Pacific chorus frog larvae and metamorphs may help in the evaluation of amphibian declines in the Sierra Nevadas.

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Cryptic coloration and shoaling preference in small fish inhabiting Blue Spring State Park, Florida

This study examined two different forms of antipredator defense used by small fish: crypsis and shoaling. We predicted that surface and mid water column dwelling fish would use shoaling as their primary defense against predators. These fish have no proximal background substrate, so the benefits of crypsis are outweighed by the benefits of shoaling. On the other hand, benthic fish should use crypsis as their primary predator defense due to the diversity of background substrates against which to camouflage themselves. Thus, these individuals would be more likely to be found alone because crypsis is more effective for solitary individuals. We tested five small species of freshwater fish to determine which species would use crypsis in a controlled environment. We filled tanks with white, green, or brown gravel and covered them with matching paper. We observed the fish for approximately 12 hours to note changes in coloration. Secondarily, we tested the preference of these fish to use shoaling or crypsis in a tank divided into cryptic and shoaling compartments, measuring the amount of time spent near each compartment. Lastly, we conducted field surveys of *Lucania parva* to determine the prevalence and effectiveness of crypsis, shoal size and substrate preferences in the field. Rainwater killifish (*Lucania parva*), sailfin mollies (*Poecilia latipinna*), and mosquitofish (*Gambusia holbrooki*) all exhibited color changes in response to treatments, whereas least killifish (*Heterandria formosa*) and bluefin killifish (*Lucania goodei*) showed no significant change in coloration. In the field, *Lucania parva* color significantly correlated with background color. However, all laboratory test fish preferred shoaling over crypsis and *Lucania parva* occurred in small shoals in the field. Despite the apparent benefits of being solitary when using crypsis as a defense, small shoals may combine the advantage of being difficult to detect with safety in numbers.

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Biology and morphology of the enigmatic South American knifefish *Orthosternarchus tamandua* (Gymnotiformes, Apterontidae)

Orthosternarchus tamandua (Boulenger) is a distinctive monotypic genus among apteronotid fishes which has a very long, straight, tubular snout, small mouth, diminutive eyes, and a thick dorsal filament that inserts far anteriorly on the body. This species used to be rare in collections, but newly collected specimens are now available. This deep-water species is distributed on the Amazon River drainage systems and was collected with trawls. Using a sample of 50 specimens

(juveniles to adult), we provide an overview of the morphology, biology and life history of *Orthosternarchus*. We describe its skeletal anatomy based on newly prepared cleared and stained specimens. The skull is greatly elongated, as reflected in the structure of the neurocranium and skull roof (especially the frontals and the ethmoid region), the extremely oblique orientation of the hyomandibula and symplectic, and the hypertrophy of the opercular bones (particularly the preopercle and interopercle). The bones of the suspensorium and jaws are not exceptionally long in comparison to other apteronotids. We conclude by making comparisons between *Orthosternarchus*, its putative sister group *Sternarchorhamphus*, and other members of the family Apterontidae. Electric organ discharges were recorded for this species at the time of collection, and they are characterized by a repetition rate far slower than that of any other apteronotid. There is bilateral asymmetry in the positioning of the eyes, which is likely correlated with their extreme reduction. The position of the anus varies markedly among adult individuals. No morphological sexually dimorphic features were detected.

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Sex-differences in electric signals allow unambiguous species recognition in a syntopic Amazonian assemblage of the knife fish *Sternopygus* (Gymnotiformes)

Four species of the gymnotiform electric fish genus *Sternopygus* inhabit the lowland central Amazon Basin: *S. astrabes* (terra firme streams only), *S. branco* (whitewater river channels only), *S. obtusirostris* (blackwater rivers and floodplains only), and *S. macrurus* (all these habitats). *Sternopygus* generate a continuous sinusoid-like periodic electric organ discharge (EOD). *S. branco* has an exceptionally low EOD rate which does not overlap with congeners. All sex and age classes considered - *S. astrabes*, *S. obtusirostris* and *S. branco* exhibit widely overlapping EOD rates. All four species exhibit sexual EOD differences in reproductively mature adults, with males exhibiting lower rates than females. In *S. macrurus* the sex difference is especially pronounced, with males generating EODs at around half the rate of females. The EOD rate ranges of sexually mature males (but not females) are completely non-overlapping between *S. astrabes*, *S. obtusirostris* and *S. macrurus*. Under a paradigm of predominantly female choice for mates, these patterns of signal diversity should in principle allow unambiguous species-recognition among mature (but not immature) specimens of species occurring in syntopy and synchrony (i.e. *S. macrurus* + *S. astrabes* in terra firme streams, *S. macrurus* + *S. branco* in whitewater river channels, and *S. macrurus* + *S. obtusirostris* in blackwater rivers and floodplains). Selective pressures related to the reduction of masking interference (sensory jamming) are unable to explain these patterns of signal diversity. Instead, inter-specific partitioning of EOD rate is inferred to have evolved in the context of mate choice and reproductive isolation.

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The effect of reproductive condition on the ecology of the cottonmouth
(*Agkistrodon piscivorus*)

Females of many temperate snake species are known to exhibit thermophilic behavior during gestation. We evaluated the influence of temperature on spatial and habitat use and spatial patterns of female cottonmouths in different reproductive conditions near the northern limit of the species range in Southwest Missouri. Sixteen individuals (8 non-gravid, 8 gravid) fitted with thermochrons were telemetrically-monitored from July through October, 2004. During gestation gravid females maintained higher and less variable body temperatures in the field and in a laboratory thermal gradient, than non-gravid females. Gravid individuals exclusively occupied habitat patches with high sun exposure which provided the highest available operative temperatures in the study area. In contrast, non-gravid females typically used forested habitats associated with lower environmental temperatures.

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Phylogenetic relationships among the Australian skinks of the Genus
"*Glaphyromorphus*"

"*Glaphyromorphus*" are small lizards from moist environments of northern and western Australia (15 sp.) and the Sunda Islands of Indonesia (4 sp.). A previous study of the Australian *Sphenomorphus* group supported "*Glaphyromorphus*" paraphyly, but only three species were included. To better understand "*Glaphyromorphus*" phylogenetic affinities, this study was undertaken with more extensive taxon sampling (thirteen Australian and two Indonesian species). Thirteen other Australian and three non-Australian *Sphenomorphus* group genera were also sampled. MtDNA were collected (ND4, 12S, 16S; ~2700 aligned positions, ~1300 variable characters, ~1000 informative characters) and analyzed using partitioned Bayesian methods. Phylogenetic analysis confirms "*Glaphyromorphus*" paraphyly and groups all species into three strongly supported clades. The first major clade includes predominantly northern Queensland taxa (*G. cracens*, *G. crassicaudus*, *G. fuscicaudis*, *G. mjobergi*, *G. nigricaudis*, *G. pumilus*, *G. punctulatus*), as well as two species from Arnhem Land & Kimberley regions (*G. arnhemicus* and *G. darwinensis*). The type species of *Glaphyromorphus* (i.e., *G. punctulatus*) is a member of this clade, so *Glaphyromorphus* is restricted to this major group. The second major clade includes the southwestern "*G.*" *gracilipes* and the geographically proximate *Hemiergis* (the genus for which "*G.*" *gracilipes* should be transferred). The final major clade contains the wide ranging "*G.*" *isolepis* group ("*G.*" *isolepis*, "*G.*" *douglasi*, "*G.*" *pardalis*, as well as the Indonesian taxa), with the morphologically distinctive (and potentially polyphyletic) *Eremiascincus* as being nested within

this group. For this final group, the simplest taxonomic solution is to transfer all "G." *isolepis* group taxa to *Eremiascincus*. Also, within the *isolepis* group, "G." *isolepis* appears to be a species complex, with some of the other members of the group being independently derived from "G. *isolepis*."

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Population genetics and metapopulation dynamics of Bluefin Killifish in a seasonally variable wetland

Patterns of extinction and recolonization may affect local population genetic structure, depending on the mode of recolonization. This provides a potential tool for investigating metapopulation dynamics in localized populations. The bluefin killifish (*Lucania goodei*) is a common and widespread species of southeastern North America that prefers shallow-water habitat but quickly disappears from seasonally-flooded wetlands during drydown events. The short lifespan and generation time of this species allow its populations to show genetic differentiation in response to events on an annual time scale. In the Florida Everglades, in which this species is common, local sites commonly dry down during the annual dry season; however, the exact sites subject to drydown in a given year vary depending on weather-related and anthropogenic influences. We investigate the population dynamics of bluefin killifish in this variable environment using newly-developed microsatellite markers. We report data from fish collected in two successive years characterized by large differences in overall patterns of drying and rehydration. We found that small but significant genetic differentiation is detectable among populations, and that these differences strongly relate to hydrology. These patterns of differentiation are not stable over time. In particular, widespread extinction and recolonization, driven by drydown events, leads to a loss of genetic differentiation between populations. We discuss the significance of our findings with regard to the genetic consequences of metapopulation dynamics.

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African frog toe biters: Predaceous diving beetle larvae (Coleoptera: Dytiscidae) found attached to specimens of *Pyxicephalus* (Anura: Ranidae)

Larvae of the beetle family Dytiscidae (predacious diving beetles) were found attached to two frogs of the genus *Pyxicephalus* during a recent examination of museum specimens. The discovery was made while collecting morphological data for a revision of the genus *Pyxicephalus*. One larva measuring approximately 4 mm is attached to a specimen of *Pyxicephalus edulis* from Tanzania. The larva is attached between digits three and four on the dorsal surface of the frog's rear right foot. The mouthparts pierced the frog's foot and are visible on the ventral side of the foot. A second similar larva (approximate length of 4.5 mm) was found attached to the dorsal surface of the front right foot of a specimen of *Pyxicephalus adsperus* from Namibia. This larval insect is attached to the center of

the foot.

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Resolving the status of *Leptodactylus fuscus* in Argentinean and Bolivian populations

The frog *Leptodactylus fuscus* has an extensive distribution throughout South America. Morphometric differences in this taxon was attributed to geographic variation (Heyer, 1978); subsequently an immunological study (Maxson and Heyer, 1988) suggested that more than one species may be hidden under this single taxon name. Allozyme data suggests that populations of *L. fuscus* cluster into three groups (Wynn and Heyer, 2001). A recent molecular study suggested that 3 or 4 evolutionary lineages could be identified within *L. fuscus* (Camargo et al, in press); however the lineages boundaries were not clearly defined. The latter problem particularly involved samples from Northern Argentina and Bolivia. Consequently, we obtained an additional 65 samples from populations from Argentina and Bolivia to perform a more detailed phylogeographic analysis of those populations. DNA was isolated from muscle or liver samples from these 65 specimens following standard protocols (Hillis et al, 1996). Double-stranded fragments of 12S and 16S mtrRNA genes were PCR amplified (Palumbi, 1996), and amplified fragments were sequenced in both directions. We obtained about 450 base pairs for each specimen. DNA data was aligned using Clustal X (Thompson et al, 1997) and phylogenetic analyses were performed using PAUP* software (Swofford, 1998). Preliminary analyses of this data will be presented and discussed. The results show two major monophyletic clades that are largely differentiated as Bolivian or Argentinean populations.

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Feeding in boas and pythons: Motor recruitment patterns during striking

Boas and pythons catch prey using a variety of motor patterns. Most boines and pythonids use preparatory trunk movements that allow the head to be projected rapidly toward the prey. The strike involves bilaterally synchronized movements of both the upper and lower jaws. In longer boine and pythonid strikes, the head is propelled toward the prey before any sign of mouth opening occurs, whereas in shorter strikes, the mouth may begin opening at or before trunk movement. Erycine boids usually use very short strikes and display no preparatory trunk movements. Many erycine strikes begin with jaw opening followed by trunk-generated movement of the whole head toward the prey, suggesting that the trunk muscles responsible for head movement are recruited after the muscles that open the mouth. Some erycine species periodically show asymmetric jaw opening during striking. They may strike either forward, laterally, or dorsally, usually to prey nearly in contact with their heads. These simple differences in behavior suggest different patterns of information flow through the nervous system. In boines and pythonids, spinal motor units are recruited at the same

time as or before bilaterally symmetric and synchronous recruitment of cranial units. Erycines, on the other hand, usually recruit cranial muscles before trunk muscles. Applying conservative assumptions about neural conduction velocities and synaptic delay suggests cranially dominated motor control of the strike in erycines and varying cranial-spinal dominance in other booids.

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Thermal tolerance and acclimation in the salamanders, *Eurycea quadridigitata* and *Eurycea chamberlaini* from South Carolina

Dwarf salamanders, *Eurycea quadridigitata*, from the coastal plain of South Carolina had a significantly higher thermal tolerance (CTM) than Chamberlain's dwarf salamanders, *Eurycea chamberlaini*, from the upper piedmont at acclimation temperatures of 5° and 15°C. This may be correlated with the higher average temperature of the coastal region, and the earlier seasonal activity and breeding of the coastal *E. quadridigitata*. Thermal acclimation significantly altered the CTM in larvae and adults of *E. chamberlaini*. Although no significant difference was found between those larvae acclimated at 5° and 15°C, those acclimated at 25°C did have a significantly higher CTM. Adult *E. chamberlaini* acclimated at 15°C had a significantly higher CTM than those acclimated at 5°C. Larval *E. chamberlaini* had a greater tolerance to CTM than adults, which may be an adaptive response to the higher temperatures of their aquatic habitat.

***CURRENS, CHRISTOPHER R.; LISS, W. J.**

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Impacts of a gape limited trout on larval northwestern salamander behavior and growth

Predation can play a strong role in the formation of amphibian population structure. Although aquatic predators have been shown to have direct negative effects on larval salamanders in laboratory and field experiments, many specific mechanisms involved in the recognition and response of larval salamanders to predators remain elusive. The potential impacts of gape limited fish on larval salamander behavior and growth is one area that has been largely under-explored. We designed an enclosure experiment to quantify the effects of gape-limited trout on larval salamander behavior and growth in the field. We specifically tested (1) whether the presence of fish too small to consume salamanders has a negative effect on salamander behavior and growth, (2) whether salamander size could be a factor influencing fish effects on salamander growth and (3) whether fish density has a negative effect on salamander behavior and growth. Three factors: treatment, initial salamander SVL and the interaction treatment* initial salamander SVL, explained 55% and 63% of the

variation in salamander growth for 2001 and 2002, respectively. The results of this study indicate that the presence of a gape-limited trout can have a negative effect on larval salamander growth and behavior and that small (<40 mm SVL) salamander growth was negatively affected more by the presence of a gape-limited fish than were large (>40 mm SVL) salamanders. However, fish density did not play a role in the reduced growth or activity levels of larval salamanders observed during the experiments. We also provide evidence to suggest that predator size could be a potential mechanism that acts as a cue for salamander predator recognition.

***CURRENS, CHRISTOPHER R.; MADEJ, M.A.**

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Impacts of watershed restoration and road decommissioning on tailed frogs in Redwood National Park

Anthropogenic landscape disturbances, such as road construction and timber harvests, can have a negative effect on both terrestrial and aquatic habitats. Although watershed restoration and road decommissioning are designed to decrease sediment loads to fish-bearing streams over the long term, within the first few years of heavy equipment work, sediment loads commonly increase. The short-term effect of watershed restoration on aquatic biota remains largely elusive. Previous work has shown that tailed frogs may be sensitive to sedimentation and can be indicators of suitable stream conditions for several obligate cold-water vertebrate species. We designed a study to investigate the effects of watershed restoration on the biomass and condition of larval tailed frogs, in 3rd and 4th order tributaries to Redwood Creek, Redwood National and State Parks, California. We sampled stream reaches in sub-basins classified as pristine (no restoration), recovering (restoration occurred >15 yrs ago) and recently disturbed (restoration occurred 1-7 yrs ago). Eight factors, including year of most recent watershed restoration and total km of roads removed, explained 63% of the variation in tailed frog biomass. The results of this study indicate that the parks current watershed restoration and road decommissioning practices have a negative impact on tailed frog biomass and condition.

***CURTIS, TOBEY H.**

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Distribution and movements of juvenile bull sharks, *Carcharhinus leucas*, in the Indian River Lagoon System, Florida.

The Indian River Lagoon system along Florida's Atlantic coast is a nursery ground for bull sharks (*Carcharhinus leucas*). Since bull sharks are a component of Florida's shark fisheries, proper management requires a better understanding of their ecology within their vital nursery areas. A sampling program utilizing longlines and rod and reel has been initiated to estimate the current abundance and distribution of bull sharks in this estuary. Tagging and acoustic telemetry are being used to investigate the movements and habitat use of the young sharks. To

date, sampling efforts have yielded the capture of 20 young-of-the-year and juvenile bull sharks (54-94 cm FL). They were captured over a broad range of salinities, depths, and oxygen concentrations, and only in temperatures > 20°C. Four sharks have been actively tracked, providing over 65 hours of movement data. Based on these preliminary results, the daily movements of these sharks appear to be confined to comparatively small core use areas (< 4 km²). There were no obvious changes in movement patterns between day and night. Continued tagging and tracking efforts will provide a clearer understanding of how this important predator utilizes its nursery habitats.

***CURTIS, TOBEY H.; BURGESS, GEORGE H.**

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The occurrence of white sharks, *Carcharodon carcharias*, off the southeastern United States, and their presence in fisheries

White sharks, *Carcharodon carcharias*, are sparsely distributed throughout the western North Atlantic Ocean, typically found in cold and temperate shelf waters. They are only occasionally encountered in the warmer waters off the southeastern U.S. and in the Gulf of Mexico. Though considered a leading cause of mortality in this globally threatened species, little has been documented on the bycatch of white sharks in fisheries. Since the white shark is now a prohibited species in the U.S. Atlantic, catches often go unreported. We have compiled 56 credible records of white shark occurrences between Cape Hatteras, North Carolina and Cape San Blas, Florida in the Gulf of Mexico from the period of 1974 to 2005, including 40 individuals incidentally caught in commercial fisheries. White sharks were most common in this region between December and April when sea surface temperatures are at their seasonal lows. Over 70% of the individuals encountered were immature based on total length. Although white sharks are relatively rare catches in the Atlantic shark bottom longline fishery (1 per 3,800 sharks), there are seasonal peaks in catch rate along certain sections of coastline. Hooking mortality rates are high (>60%). The continental shelf waters off Florida's Atlantic coast may be an important winter feeding ground for subadult white sharks. Their presence in this region makes them vulnerable to commercial longlining operations, which may be a significant source of mortality for this species in the north Atlantic.

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Molecular phylogenetics of Neotropical serrasalmine fishes (Ostariophyi, Characiformes)

The Serrasalminae are a monophyletic lineage of characiform fishes comprising ca. 75 species and 14 genera distributed in the major lowland drainages of South America. Serrasalmines are notably diverse in feeding ecology and include the

flesh-eating piranhas, scale-eating wimple piranha, and the fruit- and seed-eating pacus. Monophyly is supported by morphological and molecular synapomorphies. However, published studies based on morphological data and mitochondrial sequences recover conflicting relationships among serrasalmine subgroups, in particular the position and interrelationships of the *Colossoma-Piaractus-Mylossoma* subclade. We complement the published phylogenetic studies based on osteological data and mitochondrial sequences with new nuclear sequence data to test hypotheses of serrasalmine relationships. Our markers are the first and second introns of the S7 ribosomal protein, the recombination activation gene (*rag*) 2, and the second intron of *rag* 1. This study investigates the utility of these nuclear gene sequences for resolving serrasalmine relationships and discusses the implications of a phylogenetic framework for reconstructing the evolutionary history of this lineage.

***DAILEY, WILLIAM; LANDRY, ANDRE M.**

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Recruitment dynamics and habitat assessment of young-of-the-year Black Drum, *Pogonias cromis* Linnaeus, in Texas bay systems

The drum and croaker family Sciaenidae comprises a considerable proportion of recreational fisheries landings in the northwest Gulf of Mexico. Designation of red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*) as gamefish in 1981 increased commercial fishing pressures on confamilials including black drum, *Pogonias cromis*. Life history characteristics render adult black drum increasingly susceptible to targeted fishing pressure on large spawning aggregations in tidal passes during late winter-early spring while their young are dependent on oligohaline tidal pools and tidal creek backwaters whose habitat quality is often degraded by coastal development. Recruitment potential and habitat preference of young-of-the-year (y-o-y) black drum in Texas bay systems are not well documented. Monthly bag seine surveys for black drum were conducted from June through November 2002 at eight estuarine sites in Galveston, Brazoria, Jackson and Nueces Counties, Texas. Peak abundances were observed in June with the capture of 135 age-0 black drum that comprised over 38% of the 353 constituents taken. Standard length ranged from 27 to 158 mm and averaged 63.6 mm. Black drum ranging from 55 to 70 mm comprised approximately 50% of the total catch. Abundances differed significantly between collection sites with a Jackson County site accounting for more than one-third of all captures. Salinities for the nearly 50 collections ranged from 2 to 36 ppt. Water temperatures and dissolved oxygen concentrations ranged from 17.4 to 35.4 C, and 2.9 to 9.6 mg/L, respectively. No relationships were found between y-o-y abundances and hydrographic parameters.

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Multiple paternity assessments for three species of congeneric sharks (*Carcharhinus*) in Hawaii

Multiple paternity is expected to increase fitness and should be particularly common when females cannot evaluate males, as is the case for the brief copulatory encounters typical of most elasmobranchs. We tested for multiple paternity in single litters of three congeneric species of carcharhinid sharks found in Hawaiian waters: the sandbar shark (*Carcharhinus plumbeus*), bignose shark (*Carcharhinus altimus*), and Galapagos shark (*Carcharhinus galapagensis*). Based on eight microsatellite loci, we observed evidence of multiple paternity in both sandbar and bignose, but not Galapagos sharks. Multiple paternity may maintain genetic diversity, especially in populations that are inherently small or have undergone population decline. Hawaii provides a unique setting for this study because it hosts near pristine populations of these sharks, and can provide insight into the reproductive health of top marine predators that are susceptible to depletion.

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Detection of sexual identity through volatile components of chemical signals in red-back salamanders

Red-back salamanders (*Plethodon cinereus*) have been shown to exhibit complex social behaviors (e.g., sexual coercion and social monogamy). Chemical communication appears to mediate many of these behaviors. Much of the previous research regarding chemical communication in *Plethodon cinereus* has seemingly used relatively nonvolatile chemical signals (e.g., fecal pellets, marked substrates), and the salamanders were allowed to sample physically the chemical cue sources. Recently, it was demonstrated that red-back salamanders can detect volatile constituents of pheromones from conspecifics. We attempted to determine whether males of *Plethodon cinereus* could determine the sexual identity of conspecifics through volatile chemical signals. Male red-back salamanders were exposed to putatively volatile components of chemical signals from male and female conspecifics and a control (i.e., blank filter paper). When focal males were exposed to volatile chemical signals from males, they exhibited more stereotypical antagonistic behaviors (i.e., all-trunk raised threat posture) and chemodetection behaviors (i.e., nose tapping) than when exposed to volatile chemical signals from females and the control. We infer that male red-back salamanders can determine the sexual identity of unseen conspecifics through volatile components of chemical signals.

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Dispersal in Enneacanthini sunfishes: A test of wetland regulatory assumptions

Due to high rates of wetland destruction and mitigation, understanding the biological processes within these habitats is critical. Unfortunately, regulatory criteria revolve primarily around wetland hydrology and vegetation, ignoring the faunal community by assuming that these elements will colonize naturally via dispersal. I use molecular population genetics to investigate evolutionary and ecological processes in wetlands using a group of sunfishes that inhabits palustrine systems. The population structuring and dispersal patterns of Enneacanthini sunfishes indicate the current regulatory assumption of natural recruitment is not a valid management strategy for palustrine communities. While *Enneacanthus gloriosus* represents the highest dispersal capabilities of the tribe and would likely be able to naturally recruit to new habitats, *E. chaetodon* on the other hand would not and *E. obesus* recruitment would be questionable. These results emphasize the importance of detailed evaluations of isolated wetlands prior to impact as well as development of additional regulatory criteria.

STOYE CONSERVATION

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Geographic and historic variation in the diet and size of the massasauga rattlesnake, *Sistrurus catenatus*.

The massasauga, *Sistrurus catenatus*, is a widely distributed rattlesnake existing in a range of habitats, from swamps and wetlands to desert and prairie grasslands. Over the past 200 years, the massasauga has experienced the loss of populations and declines within populations due to many factors including loss of available habitat and intentional human persecution. To investigate the potential impacts of these factors on the size and diet of the massasauga, over 1800 museum specimens of the eastern and western subspecies (*S. c. catenatus* and *S. c. tergeminus*) were examined. Size characteristics were measured, and any stomach contents were removed and identified. In all, 136 prey items were identified, including 110 mammals, 10 lizards, 10 snakes, 5 birds, and 1 frog. There were significant differences in the diet composition of the two subspecies. The diet of the eastern subspecies included more wetland associated prey items than did the diet of the western subspecies. Historic variability in the diet and size of the massasauga was also examined. Historic trends in size characteristics and feeding ecology could be a reflection of human activities, extirpation from certain habitats, and the forced exile of the massasauga to potentially sub-optimal habitats.

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Dynamics of a poison frog Batesian-mimicry complex

Batesian mimicry results from predator association of unpalatable prey with a diagnostic warning signal, and generalization of this avoidance to palatable prey species with a similar signal. It has been argued that there should always be strong selection pressure on palatable mimics to resemble their model as closely as possible. What is the consequence of selection, however, on a mimic when more than one model species, with differing aposematic features, is available? What features will have the greatest effect on the relationship between model-mimic similarity and mimic effectiveness? We investigated the features of model-mimic similarity and mimic effectiveness using a palatable poison frog mimicry complex of three redbacked species of *Pseudis* (originally distributed in two parapatric models, and a distantly related frog species as a representative mimic). We investigated the warning signal of model and mimic species using reflectance and irradiance measurements. Model and mimic toxicity was assayed by injection of frog skin extracts into white mice. The protection of the mimic gained by sharing the warning signal with the model was empirically investigated using domestic chicks as naïve avian predators. Predators were exposed to a model species, and then generalization of learning was assessed by subsequent exposure to the exact mimic (found in sympatry with the model) and the imperfect mimic (found in sympatry with the other model). We found that where sympatric with either model, the mimic species is more similar to the model than members of its own species. Where the two models overlap, however, the mimic resembles only one model, the least numerous and least toxic. Behavior experiments indicate that less similarity to a more toxic model species is sufficient to guarantee significant protection, whereas a much closer resemblance to the less toxic model species is necessary to afford a similar benefit.

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The early evolution of viviparity in elasmobranch fishes leads to extreme remodelling of the vertebrate follicle

The elasmobranch fishes are the oldest surviving extant jawed vertebrates. Their early acquisition of functional jaws and dentition placed them in a role of apex predator early on in their evolutionary history. This role favours a life history strategy which produces: large animals, that are relatively long-lived, and which produce few offspring. To maximise their survival, offspring are relatively large and precocial. Producing large offspring requires more maternal input to the developing embryos either in the form of increased yolk, (lecithotrophy) or as extra nutrition supplied by the mother to the embryo throughout gestation, (matrotrophy). This favours a switch from an egg laying mode of reproduction to that of live bearing, (viviparity). Modes of viviparity in elasmobranch fishes include: lecithotrophy, oophagy, adelphophagy, placental analogues, and

ultimately the yolk sac placenta. A first step in producing larger offspring would be that of extended egg retention which eliminates the need for large robust egg cases, thus more nutrients can be stored in the egg for use by the embryo. These egg cells can only reach a finite size as they have to conform to certain physical and physiological parameters: i.e. gas exchange, acquiring enough nutrients, and maintaining their integrity during oogenesis and upon ovulation, where they lose the support afforded by the follicle. Here we show that remodelling of the follicle does facilitate the production of large eggs. We also indicate for the first time that some of the microvillar extensions between the oocyte and the follicle cells, (zona radiata) may go through a major remodelling: increasing dramatically in size, may take on a role in a novel transport system, and ultimately in supporting extremely large eggs during ovulation.

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Herpetofauna of Fort Donelson National Battlefield, Stewart County, Tennessee: A preliminary report.

Fort Donelson National Battlefield is a 600-acre national park situated on the Cumberland River at Dover in Stewart County, Tennessee. Located on the western edge of the Western Highland Rim, it is a highly dissected area of ridges and ravines covered mainly by oak-hickory forest. Prior to this study, despite much work in surrounding areas, no data were available on the herpetofauna of the park. To remedy this, the following objectives were established: 1) document at least 90% of the species expected to occur in the park, 2) describe the distribution and relative abundance of species of special concern, and 3) provide baseline information for developing a general herpetofaunal monitoring strategy. Sampling techniques being employed include cover board arrays and area searches in randomly selected plots, time-constrained searches along stream stretches, drift fences with pit and funnel traps at a vernal pond, night and day road cruising, and hand capture upon incidental encounters. During the first year of the study, 37 species of herpetofauna (17 amphibians and 20 reptiles) were documented. This represents 66% of the 56 species considered possible for the area. None of the species found so far are considered rare, endangered or of special concern by federal or state authorities. The study is ongoing and will continue through the summer of 2005. Voucher specimens will be housed in the APSU Museum of Zoology along with a Microsoft Excel file containing the raw data from the study. Funding for this study is being provided by the Center for Field Biology at Austin Peay State University and the National Park Service.

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Environmental and possible anthropogenic impacts on the genetic variability and structure of bocaccio *Sebastes paucispinis* off the Canadian, US, and Mexican Pacific coasts

Northeast Pacific rockfishes of the genus *Sebastes* represent an abundant and conspicuously rich assemblage of coastal groundfish species off the coasts of Canada, the US and Mexico. Many species have sustained significant exploitation from either commercial or recreational fisheries to the extent that some, such as the bocaccio *Sebastes paucispinis*, have experienced severe population declines. Central to the question of conservation and management of these ecologically important resources, in particular from the perspective of the establishment of marine reserves and no take zones, is our understanding of their population structure and possible metapopulation dynamics. Here we analyze the genetic variability of 735 bocaccio specimens collected throughout the species geographic range and genotyped with 5 nuclear loci (microsatellites) and a mitochondrial gene (control region), to study whether the ocean circulation pattern of the eastern Pacific or historical events and overfishing have shaped the genetic structure of the species. We found that the mitochondrial data from a subset of the samples revealed no phylogeographic or genetic structure, however, more variable nuclear microsatellites provided evidence of small but significant genetic heterogeneity ($F_{st} = 0.007$, $p < 0.001$, $R_{st} = 0.08$, $p < 0.001$) driven primarily by the populations at the ends of the distribution. We also found high levels of mitochondrial and nuclear molecular diversity, with the latter showing a latitudinal trend suggestive of a decreased diversity in the populations most affected by overexploitation. Our results support a very shallow level of genetic differentiation in the populations of bocaccio that appears to bear little relation with the ocean circulation of the region but may be more related to the combined effect of historical (refugial habitats) and contemporary (fishing pressure) effects on the genetic diversity of the species.

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Population structure of anadromous alewife in Connecticut: Historical and inter-location comparisons

There are concerns that some populations of anadromous alewife *Alosa pseudoharengus*, commonly referred to as river herring, have substantially declined in Connecticut. Current data on river herring populations is lacking. Assessment of historic shifts in population structure may lend insight into processes that have contributed to population decline. Limited data suggests that

river herring spawning in major river watersheds have suffered more severe declines than those spawning in coastal stream systems. Inter-location comparisons of population structure and reproductive indices may help explain different levels of population decline. River herring were sampled from Bride Brook, a coastal stream, and Roaring Brook, a tributary of the Connecticut River, in spring 2003 and 2004. Weirs were placed in both streams from March-June 2003 and 2004 for total enumeration of the spawning run. Weekly sampling was performed to assess population structure and reproductive indices. Alewives spawning at Roaring Brook showed lower levels of reproductive indices than alewives spawning at Bride Brook. The age distribution of alewives spawning at Bride Brook displayed a historic shift to younger fish. The dominant age class of spawners at Bride Brook was younger in comparison to Roaring Brook. Estimates of growth at Bride Brook showed little historic shift. Male alewives and young female alewives at Roaring Brook exhibited faster growth than their counterparts at Bride Brook. These results indicate historical and spatial variation in population structure and reproductive condition of river herring in Connecticut.

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Long-term memory in a cognitive task by turtles (*Pseudemys nelsoni*)

Cognitive abilities in non-avian reptiles have received considerably less attention compared to mammals and birds. Freshwater pond turtles (Emydidae) are long-lived, can be easily conditioned with small food rewards, and prior studies have shown that they are particularly adept at visual discriminations. We developed a procedure for training 9 Florida red-bellied cooters, *Pseudemys nelsoni*, to an instrumental task (dislodging clear plastic bottles to obtain food pellets). The training phase involved stages of shaping until the animals reliably performed the task. Then the animals were tested in a 2-choice (non-correction) design on their ability to choose the bottle containing pellets. All nine turtles learned the task and all showed a 70-100% success rate across all days. After two months of no interaction with the bottles, 6 turtles could still perform the original task and all could perform the task after retraining with fewer trials than in the original training. Turtle strategies changed, to a more "deliberative" decision making between the first and second test sessions. Turtles were subsequently tested again after 7 months of no interaction with the bottles to determine the extent of their long-term memory for this task. This study demonstrates in a laboratory context the long-term memory skills that may be used by emydid turtles in returning to nest sites, with implications for future studies in environmental conservation and enrichment for captive animals.

DAVIS, MARK A.

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Metabolism of atrazine by western chorus frogs (*Pseudachris triseriata*)

Concerns over the apparent global decline of amphibian populations have risen

substantially during the past twenty years. The Global Amphibian Assessment suggests that 32% of all amphibian species are threatened, and that 43% of all amphibian species are experiencing population declines. Hypothesized causative agents, both biotic and abiotic, are numerous and varied, but much of the recent research has focused on the effects of agricultural chemicals on developing amphibians. Atrazine in particular has been linked to a number of developmental abnormalities in amphibians, including hermaphroditism, and may be an endocrine disruptor. The physiological action of Atrazine in amphibians has been poorly understood. In this study, larval western chorus frogs were exposed to ecologically relevant concentrations of Atrazine. Water samples taken from treatment tanks were analyzed with liquid chromatography and mass spectrometry to assess the metabolism of Atrazine by the frogs, and to quantify the key metabolites. Results indicate that larval western chorus frogs are metabolizing Atrazine. However, the total concentration of Atrazine metabolites is less than the concentration of Atrazine metabolized, suggesting that Atrazine is accumulating within tissues of larval amphibians. Atrazine competitively inhibits phosphodiesterase in vitro, which may lead to the induction of aromatase, the enzyme responsible for converting testosterone to estradiol. This occurrence could explain the observed gonadal abnormalities, including sex reversal or hermaphroditism, in developing amphibians. **STOYE**
PHYSIOLOGY & PHYSIOLOGICAL ÉCOLOGY

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Effect of early acoustic experience in a neotropical frog: Do frogs learn their calls?

Vocal learning, well demonstrated in songbirds, has not been studied in anurans even though frogs and toads rely on acoustic signals for mating and many species demonstrate plasticity in their acoustic repertoire. For example, some species show geographic dialects and in others there are social correlates to call type. This study investigates the effect of early acoustic experience on the male advertisement calls of a well-studied neotropical frog, *Physalaemus pustulosus*. Males were raised in two acoustic environments, silence (no exposure to conspecific calls) and chorus (12 hours/day of exposure to a natural conspecific chorus recorded in native habitat in Panama). Males were raised in these two groups from early tadpole stage through metamorphosis (typically 20-30 days) and for the next 4-6 months. No standing water was provided during this time; males of this species only call from water so the absence of ponds insured no males were calling during treatment. When the condition of the vocal sac of each male indicated sexual maturity (typically at 19-22 mm SVL), that male was moved to an acoustically isolated chamber, housed singly, and continued to receive either silence or chorus treatment. In the chambers, each male was provided with standing water. Males began calling within days after placement in the isolation chambers and their vocalizations were recorded via an automated computer system. These digitized files were analyzed for temporal and spectral characteristics. Preliminary results show that the initial calls produced by each male appear to be typical conspecific vocalizations for this population, suggesting that early experience does not influence male vocal behaviors in this species and that the acoustic structure of anuran calls is innate.

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Uniform strain in broad muscles: A new twist on tendons

Myofilament overlap determines tension generation in all vertebrate skeletal muscle. The range of muscle fiber strains used to generate a given movement (i.e., sarcomere lengths) is therefore linked to force production. As a result, regions of a muscle experiencing different strains operate in different regions of the length-tension curve, likely decreasing whole-muscle force output. The anterior jaw adductor muscle of the cartilaginous fish, *Hydrolagus colliei*, exhibits a morphological solution to ensuring similar strains. The muscle's tendon flips 180 degrees on its longitudinal axis, such that anterior fibers insert more posteriorly and vice versa. Since insertions closer to the jaw joint experience smaller excursions during mouth opening, the anterior face of the muscle strains less than in an unflipped tendon system (the inverse is true for the posterior face). This results in nearly homogenous strain across the muscle with a flipped tendon, compared with a 10% inhomogeneity between anterior and posterior faces in the unflipped condition. We illustrate that *Hydrolagus'* morphology functions effectively in strain homogenization. The human latissimus dorsi muscle exhibits a similar morphology, indicating that this may be an ideal anatomical mechanism for strain homogenization in broad muscles attached to rotating structures and inserting relatively far from the joint. **AES CARRIER**

***DEANGELIS, BRYAN M.; MCCANDLESS, CAMILLA T.; KOHLER, NANCY E.; WETHERBEE, BRADLEY M.; RECKSIEK, CONRAD W.**

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Distribution of sharks in the U.S. Virgin Islands with an emphasis on nursery areas

Local commercial catch data in the United States Virgin Islands (USVI) on sharks is non-existent, and biological baseline data on the status of near shore sharks is very limited. As anthropogenic influences on the USVI coastline continue to increase, understanding coastal shark nursery habitat in these areas is becoming increasingly critical. Longline surveys were conducted around the islands of St. Thomas and St. John, USVIs to attempt to quantify the distribution and movements of neonate and juvenile sharks. The survey will also be used to provide a baseline assessment of shark populations. To date, the study has recorded neonates of three large coastal shark species utilizing five locations. Over all, seven large coastal and two small coastal shark species have been recorded. Catch per unit effort (CPUE) per bay has ranged from 0 - 25.8 elasmobranchs per 100 hook-hours. This data will aid federal and territorial

marine managers in accurately assessing and managing elasmobranch fishes and essential fish habitat.

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Dimethyl sulfide and associated chemicals as aggregation cues for pelagic fishes and squid

Coral reefs are frequently used as transient aggregation sites for foraging and spawning by marine fishes. Yet how marine organisms coordinate the location and timing of these aggregations remains unclear. One possibility is that organisms may use predictable changes in chemical cues associated with reefs as signals to coordinate their behaviors. Dimethylsulfoniopropionate (DMSP) is a byproduct of marine algae metabolism that is released by zooplankton grazing and other damage to algal cells. Thus, both dimethyl sulfide (DMS) and its precursor DMSP are ubiquitous scented compounds associated with coral reefs, upwelling areas, and more generally, plankton blooms. These productive areas are also the preferred sites for foraging and spawning of pelagic species, and it is possible that organisms may recruit to DMS or DMSP (DMS/P) signatures linked with these habitats. Here we begin to test this idea by investigating how temporal variation in the abundance of reef fishes and squid related to changes in DMS/P levels over the coral reefs of the Flower Garden Banks National Marine Sanctuary in the northwest Gulf of Mexico. During 2003, we recorded significant increases in water column concentration of DMS/P that were associated with coral spawning. This elevation in DMS/P was paralleled by a surge in the density of the reef-associated pelagic fishes *Caranx hippos* (crevalle jack) and *Caranx latus* (horse-eye jack) and the squid *Loligo roperi* (Roper's inshore squid) over the reef. *Manta birostris* (manta ray) and *Rhincodon typus* (whale shark) also appeared after this elevation in DMS/P. The increases in the abundance of reef-associated pelagic fishes and squid were positively correlated with elevated DMS/P, rather than with coral spawning itself, suggesting that these animals may have cued to DMS/P. These results provide the first evidence that DMS/P signatures may be used as timing cues by marine fishes and squid to coordinate aggregation behaviors.

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Between a rocket and a hard place: the herpetofauna of LEAD, south central Pennsylvania

Pennsylvania's herpetofauna is suffering under heavy anthropogenic pressures. The empirical information on the status of the herpetofauna in the state is very limited, but the general perception is that amphibian and reptile populations are in jeopardy. Among the lands most heavily impacted by human activities are military installations. From pesticide use to explosive testing, the wide array of disturbances is severe enough to produce both population decline and extinction. Designed as a long term study, my research examines the composition, relative

abundance, and population trends of the herpetofauna in South Central Pennsylvania's Letterkenny Army Depot (LEAD). Since the summer of 2003, I have surveyed the herpetofauna of this 7,000-ha site, using cover boards, drift fences, pitfalls, funnel traps, and road cruising. Thus far, I have detected 14 species of amphibians and 14 species of reptiles. The most abundant amphibian was the American toad (*Bufo americanus*) with 34.7 % of the total amphibian captures, followed by the green frog (*Rana clamitans*), with 21.8 %. The most abundant reptile was the box turtle (*Terrapene carolina*), with 62 % of the total reptilian captures, followed by both, the five-lined skink (*Eumeces fasciatus*) and the black racer (*Coluber constrictor*) with 5.3 % each. Endangered or threatened species such as the Red Salamander (*Pseudotriton ruber*), Eastern Mud Salamander (*P. m. montanus*), Bog Turtle (*Clemmys muhlenbergii*), Red-Bellied Turtle (*Pseudemys rubriventris*), and Rough Green Snake (*Opheodrys aestivus*), although historically present in this region, have not yet been found. Despite the stern perturbations associated with its military use (i.e. industrial development, logging, ammunition testing, and pollution), a complex and rich herpetofauna remains at this site. The potential for successful reintroduction of extirpated taxa and the preservation of those still remaining at LEAD are conservation objectives seemingly fitting and compatible with the military functions of the site.

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Taxonomy of bearded gobies, genus *Gobiopsis*

The taxonomy of the genus *Gobiopsis* was last studied by Lachner and McKinney (1978, 1979), who completed a revision and recognized 13 species. While working on the description of a new species I examined much of the material examined by these authors, in addition to new material added to collections since their work. My work reveals variability in some of the important characters in species-level taxonomy (e.g. the occasional presence of certain sensory pores usually absent in a given species). In addition, I found that certain characters vary ontogenetically, but this variation differs in different species. For example, unlike typical *Gobiopsis*, *G. exigua* do not develop superficial sensory canals and pores until they reach a large adult size, and many individual fish do not develop a full complement of them even at maturity. This work will result in the identification and description of other potentially new species, and the possible synonymization of two species. **STORER ICHTHYOLOGY**

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Phylogeny of Neotropical ghost electric knifefishes (Gymnotiformes: Apterontidae): New insights from the mitochondrial DNA

Apterontidae or ghost knifefishes is the most species-rich clade in the Neotropical order Gymnotiformes, with 47 valid species and 13 genera. The phylogenetic interrelationships of 12 Apterontidae genera were studied, based

in the 860 aligned bases of the mtDNA 12S and 16S, under the Cladistic tenets. Members of Sternopygidae and Eigenmanniidae were used as outgroup. The monophyletic condition of Sternarchorhynchinae, Sternarchorhynchini, Navajini, and Porotergini were not supported. The monophyly of Sternarchellini and Sternarchorhamphini were reinforced, the former clade came out as the basal-most lineage into the family. The monophyletic condition of *Apteronotus* (sensu stricto) was not supported, and remains as the most problematic apteronotid clade; *Platyurosternarchus* emerged as a sister group of *Compsaraia*. The results provided herein, differing from the historical hypotheses of relationships in the ghost knifefishes, and suggests that many of the morphological characters used to support the relationship among those taxa could represent homoplasies instead of synapomorphies. The Apteronotidae phylogeny, based in a nuclear gene is under study by the authors.

***DE SANTANA, CARLOS DAVID; CRAMPTON, WILLIAM G. R.**

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Systematics of the deep channel electric fish genus *Sternarchogiton*
Eigenmann & Ward, 1905 (Gymnotiformes: Apteronotidae)

We present a taxonomic revision of the Neotropical ghost knifefish genus *Sternarchogiton* and provide a hypothesis of phylogenetic interrelationships. Two new deep channel species are described from the lowland Amazon Basin. Cladistic analysis of 36 morphological characters yielded one most-parsimonious tree (*S. n. sp 1* (*S. nattereri* + *S. n. sp. 2*)). We present hypotheses for historical biogeography and notes on the evolution of secondary sexual dimorphism which occurs in just one species of *Sternarchogiton*.

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Use of short interspersed elements insertion polymorphism for the phylogeny of Poeciliidae and Notothenioidei

At first considered to be "junk" DNA with no known function, transposable elements are now acknowledged as representing more than a quantitatively significant part of the genomes. They also appear to play a major role in their evolution, as a source for potential exaptations as well as as a ground for recombination events. Retroposons like SINEs (Short Interspersed Elements) and LINEs (Long Interspersed Elements) are one of the most abundant repetitive elements in many vertebrate genomes and their insertion in a new location are, to a few exceptions, random, irreversible events. Presence/absence data at single insertion loci in several species can be used as characters for phylogeny. While increasingly used for mammalian phylogeny, the application of this method to fishes has been until now limited to a few groups, mainly cichlids and salmonids.

It could provide much-needed additional information for other groups of fishes, where the classical comparative anatomy and sequence data have been insufficient to bring phylogenetic resolution. Nonetheless, the extent of such loci comparisons requires the identification of homologous, insertion-containing loci and therefore the recognizability of SINEs and flanking sequences across taxa. We have isolated a SINE element that was named Bi-Ba-Butzeman. Preliminary studies on platyfish (*Xiphophorus maculatus*) have shown that this element presents a polymorphism at some sites within populations, showing it is still retroposing actively in this species. This element is part of the V-SINEs superfamily that is highly conserved and present in multiple copies in many teleosts, except in the Esocoidei-Salmonoidei clade, making it an interesting candidate for a wide scale comparative study in Acanthomorpha. It is currently being used for phylogenetic reconstruction in two acanthomorph fish groups, Poeciliidae and Notothenioidei.

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Metacanthomorpha, a phylogeny-oriented database for acanthomorph morphology

Centuries of research have accumulated a tremendous amount of systematic data for many taxa. Molecular data are easily retrievable, thanks to web-accessible databases providing a common repository that allow a simplified access to the data, but also to see whether sequences on a group or a gene are already available or not. For morphological data, there is no such repository. While several databases are already available on the net, none of them enables to crosscheck simultaneously the bibliography, statements about a given character or character state and the museum specimens that were actually studied, and the complete relevant information. Acanthomorph teleosts are so wide and plastic that their relationships are not fully resolved despite the great amount of data already published. It is actually close to impossible to make a consistent synthesis or a wide scale comparison of morphological data because of the dispersion and very important heterogeneity of the informations. The group is so vast that in some cases, specialists can not be aware that they have observed the same character state in their respective groups. We are currently developing a database enabling a global intersection of all the data (in a matrix form), restore with some detail all statements about topographical and character state identity, while still allowing to trace specimens and authors relevant to the statement. The database will ultimately be web-based and cooperative.

***DEVAERE, STIJN; JANSEN, GUNTHER; ADRIAENS, DOMINIQUE; WEEKERS, PETER**

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Phylogeny of the African catfish family Clariidae (Siluriformes) based on morphological and combined analyses: roads to anguilliformity

Clariids represent a unique range between fusiform and anguilliform morphs. Although this has been observed in other families of teleosts or amphibians and reptiles, it is never as extreme as within the Clariidae. Although originally the Clariidae were thought to have undergone an anagenetic evolution, more recent studies provide evidence that supports the hypothesis that anguilliformity evolved several times through a process of cladogenesis. In this study, it is shown that the morphological phylogenetic analysis mainly gives a reflection of the cranial evolution in the Clariidae despite the use of 18 postcranial characters (of a total of 53). A combined morphological and molecular phylogenetic analysis rather suggests the derived nature of body elongation. The corresponding morphological changes that co-occur with this elongation, e.g. increase of the number or size of vertebrae, limblessness, reduction of the eyes, and/or increasing rigidity of the skull, can be regarded as an extreme case of convergent evolution on the genus level. Many of these morphological specialisations can be linked to the specialised life style of these anguilliform morphs. The demonstrated clariid paleobiogeography seems to correspond to some extent to the principles of the refugia theory.

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A molecular approach to stomiiform phylogenetics.

Preliminary analyses of nucleotide sequence data inform estimates of the phylogeny of the order Stomiiformes (Teleostei: Stenopterygii). Stomiiformes is usually considered the most basal neoteleost order and comprises about 400 species of meso- and bathypelagic fishes. Stomiiform fishes are ecologically important, with some species extremely abundant, and are a good system for studying evolution in the deep open ocean. A robust phylogeny of the order is needed as a basis for further comparative research, but despite advances made by previous investigators using morphological evidence, many aspects of stomiiform relationships remain unresolved. Furthermore, recent data has caused the phylogenetic placement of Stomiiformes with respect to other fishes to be questioned. The present study is the first application of molecular data to the order-wide problem of stomiiform phylogeny. The current dataset is composed of nucleotide sequences from the nuclear genes RAG1 and EF1. Preliminary data from other markers is also discussed. Preliminary analysis shows some congruence between molecule- and morphology-based phylogenies, especially within Stomiidae, but there are some marked conflicts, particularly between morphology and RAG1 evidence. The complex nature of the

preliminary results highlights the need for more data to fully resolve stomiiform phylogeny, and has broader implications for choice of molecular characters in fish phylogenetics. **STOYE GENERAL ICHTHYOLOGY**

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Phylogeography of a ring species: The *Ensatina eschscholtzii* complex revisited

The plethodontid salamander *Ensatina eschscholtzii* affords a unique opportunity to study speciation because it is composed of seven subspecies with strikingly different color patterns that intergrade with adjacent subspecies in a chain of interbreeding populations around the Central Valley of California, but with reproductively isolated populations existing in sympatry where the two arms of the ring meet at its southern terminus. My research extends 60+ years of previous work on the *Ensatina* complex through phylogeographic and population genetic analyses to further trace the history and mechanisms of divergence in this textbook example of a ring species. **SSAR SEIBERT EVOLUTION/SYSTEMATICS**

***DIAVANERA, ANDRÉS H.; BARRERO, MARIA C.**

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Population declines of *Atelopus muisca* and *Atelopus lozanoi* in the highlands of Colombia.

Atelopus muisca and *Atelopus lozanoi* are two amphibian species endemic to Colombia and restricted to the Chingaza National Park. While studying local populations from 1989-1993, several herpetologists described them as being locally abundant, recording approximately 70 individuals/day. Museum collections also provide evidence that these species were once present in very high numbers. Populations of both taxa nonetheless sharply declined since the 1990s. The last record of *Atelopus muisca* took place in 1995, and *Atelopus lozanoi* was last seen in 1993. No records of any of the species exist after those years, and their conservation status is still unknown. In order to determine their status, we sampled eight out of ten known localities of *Atelopus muisca* and all four known localities of *Atelopus lozanoi* from 2003 to 2005. Our fieldwork returned no records for either species, making evident the dramatic decline of these populations. We analyzed climatic data and investigated correlation patterns between them and population trends, taking into account the presence of other possible threats. We found that a possible local threat to population persistence is the presence of the trout *Oncorhynchus mykiss* in very big numbers. Given the strong fluctuation reported in populations of other species of *Atelopus*, it is nonetheless very important to keep monitoring both taxa.

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Diet of *Rana catesbeiana* (Shaw 1802: Ranidae: Amphibia) introduced into the Andes of Venezuela

Considering the predation of this invasive frog species on native amphibian population, we identified prey items in the diet of *Rana catesbeiana* in the Andes of Mérida. During March to June of 2001, frogs were collected in a private Lagoon located at 3300 m of altitude by hand, nets and air-rifle. In total 337 stomach contents were examined. 474 prey items were found in their stomach content. This frog was deliberately introduced into the Andes of Mérida, Venezuela in the decade of 1990's without knowing up till now the purpose of its introduction. By the time of the preparation of this report, dense populations of the species occupy more than 20 freshwater habitats such as ponds, marshes, ditches and irrigation canals between an altitude of 1800 to 2600 m. Their population is spreading rapidly occupying all aquatic habitats available within a ratio of 4.3 Km from the dispersion center (Díaz de Pascual and Chacón-Ortíz, 2002). Individuals of this species were examined for the presence of *Batrachochytrium dendrobatidis* (*Chytridomycosis*) and 96% of the recently metamorphosed individuals were positive for the fungal disease (Hanselman R. *et al*, 2004). Frogs were dissected to get their stomachs and place the gut content on formalin 10%. They were divided in four age categories based on size as: Recently metamorphosed, juveniles, sub-adults and adults. We presented the data in terms of percentage of preys per each group category. The bullfrog diet varied among age groups: Stomachs of Recently metamorphosed individuals contained mainly Hymenoptera and Odonata, made up the proportion of 29.03% each, Diptera larvae (20.96%), Coleoptera unidentified (9.67%) and snails from Planorbidae family (8.06%). Juvenile diet consisted of Coleoptera (28.29%), Hymenoptera (22.36%), Odonata (9.21%), Homoptera (9.87%) and fish (5.26%). Sub-adult diet was composed of Coleoptera (34.26%), Hymenoptera (13.48%), Odonata (12.35%), Diptera (6.18%) and bullfrog juveniles (2.24%) and fish (6.18%). Adult bullfrogs contained juvenile and tadpoles of its own species (31.70%), fish from the species *Poecilia reticulata* (7.32%), Coleoptera (17.76%) and Odonata (14.63%). Diet differences were found among age groups associated to habitat use and feeding behavior.

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Juvenile lemon sharks, *Negaprion brevirostris*, do not form kin-based associations in a tropical nursery lagoon at Bimini, Bahamas

As part of an ongoing long-term life history study, a lemon shark nursery site at Bimini, Bahamas has been exhaustively sampled annually from 1995 to 2004.

Morphological measures were obtained from approximately 200 lemon sharks each year, of which 60 to 100 are young of the year (y-o-y), and fin samples were removed for subsequent genetic analyses. Using previously developed microsatellite markers, parent/offspring and sibling relationships between sampled individuals can be inferred by assigning y-o-y to distinct litters and reconstructing genotypes of the parental generation. While much has been gleaned about the mating system of lemon sharks using this genetic approach, little is known about their social behaviour and potential association within nursery areas. Therefore, the aim of this study was to detect the presence of kin-biased behavioural patterns, testing the hypothesis that nursery-bound juveniles patrol with related conspecifics more often than with unrelated ones. Using the existing genetic database, pairs of sharks spatially and temporally captured together in gill nets were identified. The relatedness of individuals within each pair was assessed using a categorical approach coupled with a chi-square analysis, while a matrix of relatedness values (r) was generated using Kinship 1.3. Juvenile sharks caught together were related in only 4 out of 91 pairs over a five year span (1996-2000), not significantly greater than expected by chance alone. Interestingly, when broken down by year, no individuals caught together were related in 1996, 1999, and 2000. As previously shown in natural salmonid populations, a complete lack of kin-association suggests kin competition may be influencing the distribution and interaction of sharks at this study site. Future applications of the existing genetic database to examine heritability of early life-history traits such as growth rates, mortality rates and litter size in lemon sharks will also be discussed.

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The contribution of mitochondrial proton leak as a heat source in lamnid sharks

Endothermic fishes can elevate the temperature of certain tissues above ambient temperature because the tissues are served by counter-current heat exchangers that conserve metabolic heat. In lamnid sharks, warming of the locomotor musculature, visceral organs, and eye/brain is associated with lateral retia, the suprahepatic rete, and orbital retia, respectively. Whether these tissues are also specifically modified for thermogenesis remains unknown. This study examines the contribution of mitochondrial proton leak as a potential heat source in two endothermic tissues in the shortfin mako shark. Proton leak is an intrinsic property of the inner mitochondrial membrane whereby protons bypass ATP synthase and diffuse back into the matrix to dissipate energy. We compared mitochondrial proton leak rates in the red muscle and liver of three shark species and hypothesized that the endothermic shortfin mako would have higher proton leak rates than the ectothermic blue shark and leopard shark. Respiration rate and membrane potential in isolated mitochondria were measured simultaneously using a Clark-type oxygen electrode and a lipophilic probe (TPMP+), respectively. Succinate-stimulated respiration rate was titrated with inhibitors of the electron transport chain to demonstrate a non-linear relationship between respiration rate and membrane potential. Although the proton leak rate in red muscle was higher than in liver for all three species, the rate did not differ significantly between endothermic and ectothermic sharks for either tissue. The

results suggest that red muscle and visceral endothermy in lamnids is achieved principally through the presence of heat exchangers and not through an increase in energetically wasteful thermogenic pathways such as proton leak. (Supported by NSF and NIH.)

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Cranial endothermy in Moonfish

Billfishes, butterfly mackerel, tunas and lamnid sharks have convergently evolved cranial endothermy. These fishes share certain behaviors and characteristics also found in moonfish (*Lampris guttatus*). Billfishes, tunas, lamnid sharks and moonfish are known to migrate from warm to cold waters and to move vertically within the water column, experiencing a wide range of seawater temperatures and rapid ambient temperature changes. It has been hypothesized that maintaining elevated temperatures of the eyes and brain stabilizes vision with change in ambient temperature in these visual predators. The purpose of my study is to determine whether moonfish have a heat source and a heat retention mechanism necessary for cranial endothermy and to describe these structures. Gross dissections and anatomical descriptions of the cranial and orbital region of moonfish will identify putative heat production and heat retention mechanisms (counter-current heat exchangers) and trace the origin of blood vessels that form heat exchangers. Transmission electron microscopy will be used to identify extraocular muscle modified for heat production (muscle cells with a high mitochondrial density and lack of myofibrils). The activity of the mitochondrial enzyme citrate synthase will be quantified to determine the aerobic capacity of extraocular muscle samples. All teleost species known to elevate brain and eye temperatures are in the suborder Scombroidei. If moonfish can maintain elevated brain and eye temperatures above ambient seawater, then they will be the most divergent species among teleosts to have cranial endothermy. If moonfish can generate and maintain cranial temperatures above ambient seawater temperatures, then this study will contribute to understanding the convergent evolution of endothermy in fishes.

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Nuclear perspectives on *Nothonotus*

The darter subgenus *Nothonotus*, genus *Etheostoma*, has been extensively studied with morphological, biochemical and mitochondrial sequence characters. All data sets strongly support a monophyletic assemblage of species. Though with extensive taxon sampling some interesting observations have been made, including apparent hybridization events and polyphyly of recognized morphological species. Interestingly there is one taxon, the redline darter, *Etheostoma rufilineatum*, which is involved in all of these seemingly unusual phylogenetic situations. The twenty described taxa from *Nothonotus* were investigated in this study using DNA sequence data from a short nuclear

ribosomal intron to test several hypotheses. Apparent aberrations as noted will also be discussed.

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**An experimental relocation of gopher tortoises (*Gopherus polyphemus*):
Does penning length affect relocation success?**

Due to altered habitat quality, fragmentation of remaining lands, and declining densities, gopher tortoise numbers have been reduced throughout their range. As an alternative to potential entombment in burrows during development, relocation of gopher tortoises to off-site habitats has become a common practice. Although frequently used, relocations have rarely maintained viable populations, and most studies are designed as mitigation measures rather than ecological experiments. Our objective was to experimentally determine whether relocations of gopher tortoises can actually result in viable populations and whether length of time in a holding pen (a so-called "soft" release) affects the probability of relocation success. Twenty-four tortoises were relocated from nearby development sites to a restored longleaf pine habitat in the Desoto National Forest in southern Mississippi. Tortoises were equipped with radio transmitters and placed into replicated intermediate-term (2-3 months) and long-term (12 month) enclosures and then released in August 2003 and August 2004, respectively. Individuals were located twice a day and then less frequently as movements decreased. By the end of the 2004 active season, 5 of 12 tortoises (42%) remained from the intermediate-term enclosures; whereas 10 of 12 tortoises (83%) remained from the long-term enclosures. For tortoises leaving the relocation site, movements varied from relatively direct courses towards the original capture locations to wandering movements around the relocation site. Mean straight-line distance moved was 1420 m (range = 610-2340 m) for tortoises in the intermediate term enclosures and 1011.5 m (range = 708-1315 m) for tortoises in the long-term enclosures. Our results indicate that length of penning does affect relocation success; however other factors such as the behavioral interactions while penned and subtle habitat differences may also have influenced relocation success.

***DIXSON, MARCIE; CARR, JOHN L.**

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Herpetofauna of two wildlife management areas in northeast Louisiana

Ouachita (OWMA) and Russell Sage Wildlife Management Areas (RSWMA) are state-owned and managed public lands in Ouachita Parish, northeast Louisiana. Both are comprised of bottomland hardwood forest within the Bayou Lafourche floodplain, although OWMA also has extensive areas of reforested agricultural

fields. Topography is flat and poorly drained with numerous sloughs and shallow bayous. Backwater flooding occurs frequently. Between the two WMA's, twenty-six 500-meter transects were marked. Sampling was conducted along the transects by means of drift fence surveys with funnel and pitfall traps, visual encounter surveys, and coverboard surveys. Total species richness assessed by all techniques was 40 for OWMA and 38 for RSWMA. Sorenson's binary coefficient of similarity comparing the two WMA's was 0.907. Visual encounter surveys (VES) completed between the months of April 2003 and November 2004 yielded a sample size of 246 individuals of 25 species for OWMA and 257 individuals of 26 species for RSWMA. The Morisita Index of Similarity (VES) for OWMA and RSWMA is 0.87. Drift fence surveys completed September through November 2003, April through June 2003 and September through November 2004 yielded a sample size of 308 individuals of 22 species for OWMA and 386 individuals of 26 species for RSWMA. The Morisita Index of Similarity for the drift fence survey of OWMA and RSWMA is 0.91. Both VES and drift fence sampling individually accounted for a little over half (55-68%) of the total species known from each WMA. The two techniques produced very similar indices of overall similarity.

DOAN, TIFFANY M.

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**Feeding niche differences within a lizard clade in Peru
(Gymnophthalmidae: *Proctoporus*)**

The lizard genus *Proctoporus* has never been the subject of an ecological investigation despite a recent increase in taxonomic and phylogenetic research on the clade. In order to examine differences in feeding ecology among species, I analyzed the stomach contents of 138 specimens of *Proctoporus* from central and southern Peru, including individuals of all six species. Feeding niches were compared among the species and differences due to sex, age, body size, locality, and elevation were examined. *Proctoporus* feeding niches were surprisingly broad with 10 different arthropod orders represented. Beetles, ants, and spiders made up the largest proportions of diets overall. *Proctoporus unsaacae* had the most varied diet of all the species (eight prey orders). *Proctoporus bolivianus* and *P. sucullucu* diets were subsets of the diet of *P. unsaacae*, whereas *P. pachyurus*, *P. guentheri*, and *P. new species* included different prey types in their diets. *Proctoporus pachyurus* and *P. sucullucu* had the greatest similarity in diets, followed by *P. bolivianus* and *P. unsaacae*. These diet similarities generally corresponded to phylogenetic relatedness. Males and females differed significantly in diet, as did adults and juveniles. This study is the first to examine feeding niche breadth and overlap within a poorly known Andean lizard clade. The remarkably high diversity of prey types eaten by these lizards indicates that, despite their small body size and reclusive nature, they actually possess the ability to subdue and consume heterogeneous prey species.

***DODD, C. K., JR.; GUNZBURGER, MARGARET S.; STAIGER, JENNIFER S.; BARICHIVICH, WILLIAM J.**

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Amphibian research and monitoring on national wildlife refuges in the southeastern United States

Since its inception in 2000, the U.S. Geological Survey's Amphibian Research and Monitoring Initiative (ARMI) has conducted intensive site-specific and regional surveys of the status and trends of amphibians on US federal lands. Research is directed at developing sampling protocols and understanding population changes and environmental factors which influence population and species declines. In the Southeast, ARMI has focused on identifying species richness and distributional patterns, particularly on national wildlife refuges in the southern Atlantic Coastal Plain. As of 2004, we have nearly completed amphibian inventories at two national wildlife refuges in Florida and begun inventories at two highly anthropogenically disturbed refuges on the Atlantic Coastal Plain. At St. Marks NWR and Lower Suwannee NWR (2002-2004), we sampled amphibians at upland sites using drift fence arrays with funnel traps (and PVC pipes at LSNWR); in wetlands (N=20), we employed dip nets, crayfish traps, automated audio loggers, and recorded data on water quality. We documented 31 species (20 frogs, 11 salamanders) at SMNWR, including the federally threatened *Ambystoma cingulatum*, and 23 species (19 frogs, 4 salamanders) at LSNWR. At drift fences, we most often captured *Scaphiopus holbrooki* and *Gastrophryne carolinensis* at SMNWR, and treefrogs (*Hyla* sp.) in PVC pipes at LSNWR. We discovered a virulent disease (*Amphibiocystidium* [?]) at SMNWR and have subsequently closely monitored populations for signs of disease. In 2004, we began intensive inventories of wetland habitats (N=38) at Harris Neck NWR, Georgia, and Savannah NWR, Georgia and South Carolina. Thus far, we have documented 21 amphibians (15 frogs, 6 salamanders) at these refuges, including new and extra-limital distributions. Emphasis in SE ARMI is now shifting toward long-term monitoring of selected sites in SMNWR and LSNWR, as it will after a second field season at the other refuges. This poster provides an overview of research and monitoring efforts to date.

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Survival and dispersal rates of Florida box turtles affected by multiple disturbance events

Studies of the Florida box turtle (*Terrapene carolina bauri*) on Florida's Egmont Key State Park/National Wildlife Refuge have focused on a wide variety of life history traits. From 1991 to 2002, field crews marked more than 2,477 different box turtles on the island, with more than 5,384 captures. Beginning midway through the project, park personnel began a restoration project designed to eliminate exotic vegetation, and an extensive series of hurricane washovers in late 1995 may have impacted the resident turtle population. We applied capture-

mark-recapture analysis to annual recapture data from the 12-year study to estimate sex and stage-specific apparent survival rates, and site-specific dispersal rates. We used the Cormack-Jolly-Seber model to investigate the temporal variation in sex-specific adult survival rates. We also compared the sex-specific survival rates between the pre- and post-disturbance periods. Adult survival rates did not vary significantly either between sexes or among years of the study. Furthermore, sex-specific survival rates did not vary between pre- and post-habitat disturbance. We used multi-state mark-recapture model to estimate the juvenile and adult survival rates, and to investigate temporal variation in these rates. We also compared juvenile and adult survival rates between the pre- and post-disturbance. Survival rates did not vary significantly either between juvenile and adult turtles, or among years of the study. Furthermore, neither adult nor juvenile survival rates varied between pre- and post-disturbance. We used multi-state models to estimate the dispersal rates among the four major study sites, and to investigate the effect of reproductive stage and sex on dispersal rates. We also compared the dispersal rates between the pre- and post-disturbance. Dispersal rates varied significantly among the four sites. Interestingly, pre- and post-disturbance dispersal rates varied significantly at all four sites. Dispersal rates were generally higher during the pre-disturbance sampling periods compared to post-disturbance.

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A preliminary review of the sand tilefish genus *Hoplolatilus* (Malacanthidae)

Hoplolatilus usually inhabit moderately deep sand-coral rubble bottom types at 20-70 m depths where they construct burrows that they may inhabit in pairs. They are widespread in the: tropical and subtropical central Pacific (including the Society Islands), Indo-west Pacific region, (Philippines, Taiwan, East China Sea, VietNam, South China Sea, Indonesia, Micronesia, New Guinea, northern and western Australia), Indian Ocean, (Andaman Sea, Maldives, Mauritius), and the Red Sea. The genus *Hoplolatilus* belongs to the sand tilefish family Malacanthidae (Dooley, 1978) and consists of two subgenera (*Hoplolatilus* and *Asymmetrurus*; Randall and Dooley, 1974) and 11 nominal species (Earle and Pyle, 1997). Allen and Kuiter (1989) described a new species *Hoplolatilus luteus* based upon a single specimen collected in 1988 while diving off Flores, Indonesia at a depth of 32 meters. Allen and Adrim (2003; p.37) later considered *H. luteus* as an endemic of Flores & Bali, Indonesia. *Hoplolatilus luteus* Allen and Kuiter, 1989, appears to be a junior synonym of *H. fourmanoiri* Smith, 1963 based upon live coloration and other morphological and molecular data.

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The physiology and ecology of the Rubber Boa (*Charina bottae*) in southeastern Idaho

Rubber boas (*Charina bottae*) are small, secretive snakes found in a variety of habitats throughout the northwestern United States. We studied the physiology and ecology of rubber boas in southeastern Idaho over several years in the field using radiotelemetry and mark-recapture techniques and in the laboratory by examining thermal preference and the effects of temperature on whole-animal physiology. Free-ranging rubber boas remain hidden much of the time but may actively thermoregulate to maintain stable, high body temperatures during gestation and digestion. Rubber boas are often nocturnally active at relatively low body temperatures (6-20 C) resulting in low levels of physiological performance. For example, while active at night, rubber boas experience body temperatures that result in performances only 10% to 40% of maximal. Rubber boas may partially compensate for this performance reduction by physiologically reducing the cooling rates of their heads. Mark-recapture studies reveal that rubber boas can be very abundant in some habitats, outnumbering other more frequently encountered species of snakes. However, female rubber boas reproduce on average every three years and have relatively small litters (3-7 babies). The low reproductive rate of this species apparently requires a high rate of juvenile survivorship and a long life span to maintain stable population sizes.

***DOUGLAS, MARLIS R.; HOPKEN, MATT W.; DOUGLAS, MICHAEL E.; HUYVAERT, KATE P.**

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Introgressive hybridization and purity assessment of Rio Grande Cutthroat Trout (*Oncorhynchus clarki virginalis*) populations

Numerous factors contribute to the decline of indigenous fishes in Western North America. While habitat alteration is a major concern, introductions of alien species are increasingly recognized as a more serious threat to long-term survival of native fishes, and often have unanticipated and deleterious effects. Non-native trout have replaced Rio Grande Cutthroat Trout (RGCT; *Oncorhynchus clarki virginalis*) in 90-95% of the latter's historic distribution. Recovery efforts focus on maintaining 'genetically pure' (less than 1% introgressed) 'core populations' of RGCT for broodstock development, as well as 'slightly introgressed' (less than 10% introgressed) 'conservation populations' that express the form's unique ecological and behavioral characteristics. Successful allocation of RGCT populations to management categories requires identification of alien alleles in RGCT populations. To accomplish this, two fluorescent-based molecular genetic approaches, BIAMs (bi-allelic-markers) and PINES (PCR-amplified interspersed nuclear elements) were employed to assess introgression of RGCT populations by Rainbow Trout (RBT; *O. mykiss*) and inland cutthroat trout (CTT, *O. clarki*) subspecies. Both methods examine genetic variation at nuclear loci by assessing

presence/absence of species-diagnostic alleles. Each differs in the number of alleles (loci) that are amplified using a single primer-pair. For BIAMs, only two alleles (i.e., a single locus) are amplified by each primer pair and allele size is the diagnostic character. Each locus is independent and backcrossed individuals will show a mix of RGCT and alien alleles. For the PINES approach, multiple loci are amplified with each primer pair. Only some loci will be species diagnostic, whereas others will be uninformative. Only loci that are diagnostic for alien species are counted, and only presence (but not absence) of these alleles is considered. Samples (4-30 individuals/ population, 30 total populations) were analyzed using these molecular screening methods. Levels of introgression for each population were determined with 99% confidence. Problems associated with ancestral polymorphism are discussed.

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Molecular diversity in *Sistrurus* (Viperidae)

The genus (*Sistrurus*), the most basal of the Rattlesnakes, consists of two North American species. The Pygmy Rattlesnake (*S. miliarius*) is found in the southeastern United States from NC thru peninsular FL and west to central OK and east TX and consists of three subspecies (*S. m. miliarius*, *S. m. barbouri* and *S. m. streckeri*). The Massasauga (*S. catenatus*) is distributed from southeastern Canada across much of eastern/central United States to southeastern Arizona and is also represented by three subspecies: *S. c. catenatus* (Eastern Massasauga), *S. c. tergeminus* (Western Massasauga), and *S. c. edwardsii* (Desert Massasauga). It is a federal candidate species for listing, and is state endangered over its range (except MI). We examined molecular diversity within the Massasauga and evaluated the validity of its current taxonomy by sequencing 840 bp from two mtDNA genes (ATP 8 and 6), from 59 Eastern, 31 Western, and 29 Desert forms sampled range-wide. We also included 14 *S. miliarius* and rooted our ML tree with *Agkistrodon*. Results indicate that Massasauga and Pygmy rattlesnakes differ by 17% sequence divergence. Eastern and Western Massasauga differ by 11%, whereas Western and Desert massasauga diverge at 0.5-1%. By comparison, Watermoccasin and Copperhead differ from one another by 9%, and by 18.5-20% from Pygmy Rattlesnake. Given these levels of divergence, *Sistrurus* is clearly a candidate for taxonomic revision at several levels.

***DOWD, W. WESLEY; BRILL, RICHARD W.; BUSHNELL, PETER G.; MUSICK, JOHN A.**

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Metabolic rates and bioenergetics of juvenile sandbar sharks (*Carcharhinus plumbeus*) in the lower Chesapeake Bay

We measured the standard and routine metabolic rates (SMR and RMR) of juvenile sandbar sharks (*Carcharhinus plumbeus*) over the range of body sizes and temperatures characteristic of northwestern Atlantic coastal summer nursery areas. The allometric equations relating SMR (mg O₂/hr) to body mass (kg) were: SMR=65 (+/-15) x M^{0.73} (+/-0.14), SMR=120 (+/-17) x M^{0.79} (+/-0.08), and SMR=207 (+/-28) x M^{0.63} (+/-0.07) at 18C, 24C, and 28C, respectively. The overall SMR Q₁₀ was 2.9+/-0.2. The allometric equation for RMR was: RMR = 213 (+/-38) x M^{0.79} (+/-0.11) at 24-26C. RMR averaged 1.8+/-0.1 times the SMR. The estimated additional costs of swimming in a curved path was 7.7+/-1.1%. When corrected for this effect, the mean ratio of RMR to SMR equaled 1.6+/-0.1. There was no significant correlation between body mass and the ratio of RMR to SMR. Assuming maximum metabolic rate is two to three times SMR (as in other elasmobranchs), sandbar sharks use approximately 50-80% of their metabolic scope to sustain their routine continuous activity, leaving limited potential increase in oxygen delivery to fuel somatic growth and reproduction. We then estimated daily ration and seasonal prey consumption rates for six age-classes of juvenile sandbar sharks in the lower Chesapeake Bay summer nursery area using a bioenergetics model with habitat-specific data on growth rates, diet composition, water temperature (range 16.8-27.9C), and population structure. The predicted mean daily rations ranged between 2.17+/-0.03 (age-0) and 1.30+/-0.02 (age-5) percent body mass per day. These daily rations are higher than earlier predictions for sandbar sharks, but are comparable to those for ecologically similar shark species. The total nursery population of sandbar sharks was predicted to consume approximately 124,000 kg of prey during the 4.5 month stay in the Chesapeake Bay nursery, an insignificant top-down effect on the Chesapeake Bay ecosystem in comparison with teleost piscivores and humans. **AES GRUBER**

***DRAKE, DANA L.; ALTIG, RONALD; WALLS, SUSAN C.**

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Post-injury regeneration of the major components of the oral discs of larval ranids

Awareness of oral defects in tadpoles is increasing, although interpreting the etiology of these defects has only begun. Injuries are one of the potential causes of oral defects, but little is known about the ability of anuran larvae to regenerate

the oral disc after suffering injuries, or the impact oral injuries have on size at metamorphosis. We reared three clutches of *Rana sphenoccephala* tadpoles from hatching to metamorphosis and performed one of four surgical treatments on individuals when they reached Gosner stages 32-34. We surgically removed portions of either the marginal papillae, tooth rows, or jaw sheaths, or made an integumentary incision outside of the oral disc (control). We preserved tadpoles in formalin and quantified regeneration at 1 and 2 weeks post-surgery (n= 240 tadpoles/week, or 60 tadpoles/treatment/week). The remaining tadpoles (n= 240, or 60/treatment) were allowed to metamorphose and were measured (SVL) and weighed when they reached Gosner stage 41. All treatments included some tadpoles with complete regeneration of the removed portion of the oral disc within the first week; there were significantly more tadpoles per treatment with complete regeneration after 2 weeks ($p = 0.05$). Only the marginal papillae treatments regenerated structures from other components of the oral disc (i.e., teeth and tooth ridges). There was no significant difference among treatments or the three clutches in SVL or mass at metamorphosis. Regeneration of mouthparts was not always perfect, and many of the resulting oral defects in this study resembled those reported by the authors to occur in tadpoles from natural sites. These results indicate that (1) tadpoles regenerate their mouthparts and do so quickly; (2) injury is a source of oral defects in tadpoles; and (3) small-scale defects of the oral disc caused by injury have little impact on overall size of newly metamorphosed frogs.

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Preliminary phylogenetic examination of the family Malacanthidae

Tilefish have traditionally been separated into two families, Branchiostegidae with three genera and 21 species and Malacanthidae with two genera and eight species, based on morphological and behavioral characteristics. Currently, the family Malacanthidae contains two subfamilies; Latilinae and Malacanthinae. Three genera with 28 species are included in the Latilinae and two genera with 14 species are included in the Malacanthinae. A recent alternate classification places the malacanthids into the percoid family Dactylopteridae with four subfamilies, Branchiosteginae, Malacanthinae, Hoplolatilinae and Dactylopterinae. Morphological and molecular characters are examined to determine the monophyly of the current family Malacanthidae.

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Development of a hyperbaric trap-respirometer for the capture and maintenance of live deep-sea organisms

A major obstacle to the investigation of deep-sea fishes is the lack of instrumentation to retrieve them from their habitat alive, particularly fishes with

physoclistous swimbladders. In order to perform physiological experiments on deep-sea fishes under in situ but controlled conditions we constructed a high-pressure fish trap-respirometer to capture deep-water fishes at depth and return them to the surface alive at in situ pressure and temperature. Pumps and instrumentation connected aboard ship or in the laboratory are used for maintenance of the animal and experimentation. The trap was designed so that respiration rates, pressure tolerance, and metabolic responses to various gas concentrations (CO₂ and O₂) could be examined in a controlled environment. The trap is deployed as an autonomous lander or free vehicle to depths of 4000 m. Once on the seafloor a fish is captured on a baited hook which triggers the reeling of the fish into the pressure vessel and closure of its sealing door. Initial experiments have successfully captured and retrieved the macrourid *Coryphaenoides acrolepis* from depths of 1500 meters. Data on rates of oxygen consumption and pressure tolerances will be presented.

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Demographic trends of the River Cooter (*Pseudemys concinna*) over a decade of monitoring

Effective conservation planning of threatened species relies heavily on demographic data such as population size and recruitment rates. Detecting demographic trends for long-lived species requires long-term monitoring. Since 1994, we have been monitoring a population of the state endangered river cooter, *Pseudemys concinna*, at a floodplain lake in southern Illinois. Our objectives were to determine if there was a trend in population size, if population structure varied between years, and if growth rates varied by cohorts. Over the last decade, the estimated size of the population more than doubled. Adult sex ratio, adult to juvenile ratio, and size class structure did not significantly differ across years, implying that all sex and size classes increased at the same rate. We also observed wide variation in growth rates among cohorts which may explain the wide variation in age of sexual maturity observed in many turtle populations.

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Fidelity to over-wintering refugia in the Eastern Massasauga (*Sistrurus c. catenatus*)

Ectotherms must enter dormancy during periods when the environment does not permit the effective regulation of body temperatures. Because of reduced motor performance during these periods and the risk of mortality, the selection

of and ability to locate refugia are critical to survival. Although strong fidelity suggests localized activity near the refugia, many species exhibit vernal and autumnal long-distance migrations. Contrary to the general trend in temperate-zone pitvipers, the Eastern Massasauga (*Sistrurus c. catenatus*) shows neither communal over-wintering nor migratory patterns, therefore activity should be centered around winter refugia. To test this prediction, we undertook a three-year radiotelemetry and six-year mark/recapture study at a population of *S. c. catenatus* in south central Illinois. We found the refugia of individuals were aggregated, suggesting fidelity to specific area rather than a specific refugium. We found snakes entered over-wintering sites on average 90 m from their previous site and seasonal activity was localized activity near that site.

***DUNCAN, KAREN; LAUER, ANTJE; HARRIS, REID N.**

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Analysis of the cutaneous bacterial community of the salamander, *Plethodon cinereus*: Casuals and epibionts

Several studies have identified cutaneous bacteria, which produce antifungal antibiotics, from different salamander species. We hypothesize that cutaneous antifungal bacteria can play a role in preventing fungal attack of eggs and may play a role in preventing pathogenicity of the chytrid *Batrachochytrium dendrobatidis* on adults. We examined salamander skin of the plethodontid salamander *Plethodon cinereus* using a scanning electron microscope and found an association between bacterial cells and skin pores. These results suggest the possibility of an epibiotic community, which is defined as a resident attached community. The antifungal bacteria that we have isolated and identified to date through sequencing of part of the 16s RNA gene are similar to bacteria found on plants and in the soil. We investigated whether the cutaneous antifungal bacteria are casuals or epibionts through washing salamanders and then swabbing of the salamanders' remaining cutaneous flora. The bacteria from the rinse solutions and swabs were compared using denaturing gradient gel electrophoresis (DGGE) and banding patterns were found to be different between the two, suggesting that the casuals were rinsed off while the epibionts remained on the salamander. Bands will be excised, reamplified and the 16s RNA gene will be sequenced. Taken together with other work in our laboratory, these results suggest a portion of epibiotic bacterial flora produce antifungal compounds and that a large proportion of salamander individuals can house epibiotic antifungal bacteria.

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Reproduction, diet, and habitat utilization of leopard sharks, *Triakis semifasciata*, in Humboldt Bay, California, U.S.A.

The leopard shark, *Triakis semifasciata* (Girard), endemic to the eastern North Pacific, is one of the most common elasmobranch species found along the

California coast. Several northern California bays and estuaries, including Humboldt Bay, are important nursery areas for this species. A total of 312 females were sampled in Humboldt Bay during the spring over three successive years. All females examined were determined to be mature and ranged in size from 120-154 cm LT. Only three adult males were caught in the study area and all were tagged and released. Overall, of the 153 females examined in early spring 130 contained term-embryos. Each embryo was encapsulated in a clear membranous sac and all appeared to be near-term. The number of embryos per female ranged from 1-37 with the trend being that larger females had more embryos. A total of 1,446 embryos were sexed with a male:female ratio of 1:0.93 that was not significantly different than a 1:1 ratio ($P > 0.05$). Embryos ranged from approximately 17-20 cm LT. Of the 159 individuals examined in late spring no females with embryos were found and all, with the exception of four individuals, were observed to be ovulating. A total of 239 stomachs were examined, of which 196 (82.0%) contained prey items. Overall, fish eggs (*Atherinopsis californiensis*), at 48.0%, had the highest %IRI, followed by the cancrid crabs, *Cancer antennarius* (29.8%) and *C. magister* (11.6%). All other prey items were of relatively minor importance, cumulatively representing 10.6% of the overall diet. Leopard sharks were observed foraging and this behavior is described.

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The anoles of the Pacific region

Accidental and deliberate introductions of amphibians and, especially, reptiles, are now commonplace. Many introduced species are still restricted in their non-native ranges to the immediate vicinity of their initial introduction (e.g., *Dendrobates auratus* on Oahu) whereas others have spread rapidly (e.g., *Anolis* [*Norops*] *sagrei* [Polychrotidae] in the southeastern United States, *Bufo marinus* [Bufonidae] in Australia). Some have become virtually pan-tropical in distribution (e.g., several species of *Hemidactylus* [Gekkonidae], *Ramphotyphlops braminus* [Typhlopidae]), and others threaten to do so. Among the latter are *Anolis carolinensis* and *A. sagrei*. *Anolis carolinensis* is native to the southeastern United States and *A. sagrei* occurs naturally on many islands in the West Indies. Established introduced populations of *A. carolinensis* occur in the Pacific Region on all major islands in the Hawaiian Archipelago, in the Ogasawara (Bonin) Islands southeast of Japan, on Okinawa in the Ryukyu Islands, and through the Marianas to Yap and Palau. A failed introduction on Sand Island, Midway Atoll, is documented and a number of these lizards were intercepted and exterminated when they arrived in cargo on a dock in Sydney, Australia. *Anolis sagrei* is established on Oahu, where it is expanding its range, and has recently been reported on Kauai and Taiwan. A third anole, *A. equestris*, is established on Oahu. In expanding their ranges on islands in the South Pacific, anoles will face challenges from arboreal predators and competitors not experienced by members of the genus as they colonized islands in the West Indies prior to the arrival of humans in that region.

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Habitat use by the bog turtle (*Glyptemys muhlenbergii*) in a south-central Pennsylvanian late-successional wetland

Due to declines from habitat alteration and destruction, the bog turtle *Glyptemys muhlenbergii*, has been listed as threatened by the U.S. Fish and Wildlife Service and as endangered by the Pennsylvania Fish and Boat Commission. Despite the protection of this species, bog turtle habitat continues to be developed leading to the further decline of populations. Measures have been taken to protect bog turtle habitat by requiring that suitable sites be searched for bog turtles prior to permitting development. However, these measures are based on studies of classic bog turtle habitat typified by open canopied, shallow wetlands with soft, mucky substrates dominated by marsh graminoids. One bog turtle site in south-central Pennsylvania has undergone changes due to alterations of the hydrology that occurred in the 1970s. The classic habitat that surrounded the former reservoir has succeeded to a swamp forest dominated by mature red maple, white pine, and highbush blueberry. Although a modest amount of classic habitat is present at this site, recent surveys revealed that many of the turtles remained in the swamp forest and did not venture into the open marsh. A need exists for research of bog turtle habitat use in these late-successional wetlands in order to revise our view of suitable habitat for bog turtles. To evaluate the significance of these late-successional habitats to bog turtles, we radio tracked 10 bog turtles over one year to determine habitat use. Home ranges of individual turtles were lower than in many other studies and home ranges of some individuals did not overlap. Several turtles remained in the swamp forest during the entire tracking season. Our results suggest that disrupting succession that threatens to overtake the remaining classic bog turtle habitat may be necessary in order to help promote recruitment and ensure the long-term viability of the population.

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Clinal variation in morphology of *Lythrurus umbratilis* (Cypriniformes: Cyprinidae) in the Ohio River basin

Prior to this study, inadequate documentation of morphological variation in the redbfin shiner (*Lythrurus umbratilis*) has impaired the ability to identify many eastern populations. Meristics, morphometrics, tuberculation, pigmentation, and nuptial male coloration of selected populations of *L. umbratilis* were examined in order to assess patterns of geographic variation and species limits in the Ohio River basin. In the summers of 2003 and 2004, quantitative and qualitative data were collected from over 600 specimens from 29 localities in Kentucky and surrounding states. Analyses of these data demonstrate morphological variation in *L. umbratilis* is clinal along the length of the Ohio River basin. Eastern populations have less black in the dorsal fin of breeding males, lower mean scale counts, and are more slender than western populations. Spatial autocorrelation analyses of univariate and multivariate meristic variables suggest clinal variation

is well defined from the mouth of the Ohio River upstream to southern Ohio and West Virginia. The cline is not as defined into central and northern Ohio, because these populations have relatively high meristic counts. These analyses suggest recognition of additional species in the Ohio River basin is not warranted, but the documentation of the intraspecific variation is relevant in understanding evolution and management of biodiversity of regional fishes.

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Genetic differentiation within and among river basins in an upper-Amazonian leaf litter frog

Understanding the origins and significance of biodiversity requires that we understand the historical, geographical and ecological factors that influence diversification across geographical and temporal scales. In the neotropics, such approaches take on added significance as we seek mechanisms that might underlie the hyperdiversity found in this regions, in particular the amphibian diversity of the upper Amazon slopes. To this end, we are evaluating the distribution of genetic diversity across the upper Amazonian range of a small, leaf litter frog, *Eleutherodactylus ockendeni*: 1. among individuals across a single landscape (25 km²) within the Jatun Sacha Biological Reserve, 2. among locales within a single river drainage (Rio Napo), and 3. among river drainages across the species' Ecuadorian distribution. At the broadest geographic scale we are investigating phylogeographic patterns using 743 base pairs of mitochondrial cytochrome *b* DNA sequence and have found deep divergences (maximum > 17%) among haplotypes, lack of monophyly at the drainage level but complete compartmentalization within most of the 15 sampled locales. At the local landscape level we are examining patterns of variation within and among six localities in both the aforementioned mtDNA and minimally 7 species-specific DNA microsatellite loci that we developed. By comparing fine-scale genetic diversity to regional patterns of differentiation we hope to elucidate the evolution of intraspecific diversity for one member of the most speciose frog genus.

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The effects of density and food on morphology and behavior in larval *Ambystoma macrodactylum columbianum*

Cannibalistic behavior occurs in many animal groups including planaria, rotifers, gastropods, insects, arachnids, fish, amphibians, birds and mammals.

Environmental factors that have been documented to influence this behavior include food availability, conspecific density, and the presence of vulnerable conspecific prey. Cannibalism has been documented in larval populations of many species of Ambystomatid salamanders including in several mountain populations of the larval central long-toed salamander (*Ambystoma macrodactylum columbianum*). Furthermore, it has been reported that some individuals within these populations possess a "cannibal" morphology, characterized by a disproportionately large head and enlarged vomerine (i.e., roof of mouth) teeth. Although both the behavior and morphology have been reported in these natural populations, this "cannibal" morphology has not been successfully induced under controlled settings. For this study, a laboratory experiment was performed to examine the effect of high conspecific density and limited food availability on the development and/or maintenance of the "cannibal" morphology and behavior in groups of late stage larval *A. m. columbianum*. Specifically, larvae were reared under conditions of no, low or high conspecific densities and low or high levels of food for six weeks. Ultimately, the "cannibal" morph was not induced under any of these conditions. However, not surprisingly, larvae reared in the high food treatments grew larger than larvae raised in the low food treatments. In addition, correlations were found between size variation, cannibalism and aggression across the treatments.

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Realistically dealing with Florida's exotic species dilemma

At least 40 non-native amphibian and reptile species have been established in Florida >10 years. South Florida has only 10 native and at least 30 exotic lizard species. In July 2004, the Florida Fish and Wildlife Conservation Commission created an Exotic Species Coordination Section with 7.5 full-time employees whose mission is to minimize the impacts of exotic species on native wildlife populations by integrating exotic species prevention, research, management, and education/outreach throughout the agency. Assessing the potential invasiveness of a species is problematic; 14 of Florida's exotic reptile species occur elsewhere only in their native range, and nine species occur elsewhere only on islands. Successful invasion depends upon suitable climate and habitat, species' characteristics, and the inoculation rate, which is high in Florida (exacerbated by hurricanes). Miami receives the most wildlife imports in the country, and numerous reptile dealers and collectors in the area contribute to the escape or release of exotics, sometimes in attempts to establish exploitable populations. Over 5,000 persons are licensed to sell reptiles in Florida and possess >2 million reptiles (>150,000 venomous). Eradicating established populations is usually impractical and unrealistic, so preventing future introductions is the key, along with an early warning system to detect potentially harmful species before establishment and dispersal. The law against releasing exotic species is difficult to enforce and commonly violated; long-term education and interagency cooperation are important. Although most exotic herpetofaunal species primarily occur in synanthropic habitats, 17 species readily invade natural habitats. Most introduced species will not become established, and only a small percentage will become problematic. Competition with native species may be ecologically insignificant because of abundant resources, but the establishment of large

predatory species (e.g., *Python molurus*, *Boa constrictor*, *Varanus niloticus*) may threaten listed wildlife species, and restricting the trade or keeping of certain species may be warranted.

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Development of the Little Skate (*Raja erinacea*) as an in situ bioindicator of environmental spermatotoxicants

Epidemiological and wildlife studies have implicated environmental pollutants in declining sperm production, but few of the ≈87,000 chemicals added to the environment have been tested for spermatotoxicity. To detect and localize the presence of spermatotoxicants in the natural environment, the little skate was selected for its potential as an *in situ* bioindicator species. Skates are nonmigratory and widely distributed in coastal waters. Also, the simple organization of the elasmobranch testis facilitates stage-by-stage analysis of spermatogenesis. Skates were collected from a highly polluted Superfund site (New Bedford Harbor, NBH, MA) and four different reference sites (ME, NH, MA). Analysis of testicular cross-sections showed that NBH skates, when compared to reference skates, had significantly fewer spermatocysts (germ cell/Sertoli cell clones) in the spermatocyte and early spermatid stages of development. Although the number of spermatogonial cysts did not differ, the percentage with apoptotic cells was significantly greater in NBH than in reference skates (24 vs. 14%). Moreover, although apoptosis was restricted to spermatogonial stage cysts in controls, apoptotic gonocytes were seen in the germinal zone of two NBH skates. Consistent with high levels of PCBs known to be present in NBH, P4501A1 mRNA (a marker of arylhydrocarbon receptor activation) was highly induced in muscle of all NBH skates and in testis of 6 skates from the same group (n, 9), when compared to reference skates (n, 12). Also, testicular aromatase mRNA was elevated ≈2 fold in NBH, but -tubulin mRNA and other markers showed no clear site-related differences. These results provide clear evidence of spermatotoxicity and altered gene expression in skates resident in a highly polluted environment, and further suggest that the defect involves the developmental advance of spermatogonial clones into meiosis and spermiogenesis. Supported by NIEHS (P42ES07381); EPA (STAR R825434); NOAA (MIT Sea Grant); and NICHD (2T32 HD073897). **AES GRUBER**

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Movements and diel behavior of *Sternotherus minor peltifer* in west-central Tennessee: A preliminary report

Little information is available on the movement behavior of any of the subspecies of *Sternotherus minor*. Most published studies on the species focus on other aspects of its life history and phylogeny. This paper presents the preliminary findings of an on-going investigation begun in May 2004 of movements and diel

activity of a population of *S. minor peltifer* in Whiteoak Creek, a tributary to Kentucky Lake (impounded Tennessee River) in Houston and Humphreys counties, Tennessee. Using radiotelemetry and Geographic Information System (GIS) technologies, 14 individuals (6 males, 8 females) were relocated once weekly for periods ranging from 9 to 39 weeks, and their movements plotted in relation to assorted physical and biological features in and along the stream. Movements over the 24-hour cycle were also monitored on seven occasions. Data obtained to date suggests a linear-shaped home range (mean 341.4 m) extending along stream stretches with ample shoreline cover. Of the initial capture plus relocation points documented, 225 (62%) involved limestone bluffs, 70 (19%) fallen trees, 36 (10%) vegetated limestone outcrops, 27 (7%) banks with exposed tree roots, and 4 (2%) other features. Mean length of home ranges was 341 m, with no significant difference between that for males (335 m) and females (346 m). Data on movements during the 24-hour cycle suggests a nocturnal pattern of behavior. Funding for this project is being provided by the Center for Field Biology, Austin Peay State University.

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Sexual dimorphism and growth in the Bog Turtle (*Glyptemys muhlenbergii*)

The bog turtle (*Glyptemys muhlenbergii*) is an unusual turtle in that males are larger than females. We compared sexual size dimorphism (SSD) based on centerline carapace length (CL) between 77 male and 101 female adult bog turtles captured in Maryland from 1992-2004. The mean centerline CL for males (95.5 mm) was significantly larger than for females (91.6 mm). We also compared SSD based on maximum CL for 208 males and 279 females caught during the same period. Mean maximum CL was also significantly greater for males (97.2 mm) than for females (93.3 mm). We found no significant difference in centerline CL and maximum CL for males and females between 5 watersheds within Maryland. In addition to SSD tests, we compared growth curves for 208 males and 279 females. Previously published data for bog turtle growth in other states shows a range wide north-south cline in mean centerline CL for both sexes with progressively larger individuals further south. Our Maryland data closely agrees with this pattern.

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Isolation of microsatellite markers and small spatial scale population structure analysis in the treefrog *Hyla saxicola* (Anura, Hylidae)

Two microsatellite markers were isolated, characterized and used to assess the structure of populations of the treefrog *Hyla saxicola* at a small spatial scale. This

anuran species is broadly distributed at the montane meadows of the Serra do Cipó and is known to be endemic from the Espinhaço mountain range (Southeastern Brazil). A genomic library was constructed using DNA extracted from tadpoles. Four microsatellite regions were located through library screening using radiolabelled fish microsatellites. Two of these regions, denominated P59G and P117H, have been characterized and showed high variability (11 and 10 alleles, respectively, were found in 75 tadpoles from five independent streams), indicating that these loci are suitable for studies on population genetic structure. Overall F_{st} was 0.056. Some studied populations showed isolation by distance, but did not show an increase of variation on F_{st} with the increase in geographic distance, as it would be expected in drift-gene flow equilibrium conditions. The microsatellite markers revealed lack of pairwise genetic differentiation in spatially close populations and also in some distant ones, a pattern that may be caused by the combination of past event effects and limited migration ability contingent upon good habitat conditions for frog movement.

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Age and growth determination of a deep-sea centrophorid shark, *Centrophorus cf. uyato*, from the Cayman Trench, Jamaica, W.I.

Over the two-year period between August 2000 and March 2002, 54 specimens of *Centrophorus cf. uyato* were captured (7 males and 47 females) from depths of 400-913m. Both anterior and posterior dorsal fin spines were cross-sectioned for analysis. Readings between the first and second dorsal spines were compared within and between spines. The average percent error was determined for anterior and posterior spines individually, as 7.15% and 5.33%, respectively, and for the accepted readings between the two spines as 15.3%. Overall, ring visibility in the posterior spines was greater than in the anterior spines yielding higher values and more accurate results. Growth curves were constructed and size and age at maturity were determined and compared between both anterior and posterior dorsal fin spines using all readable samples. **AES CARRIER**

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Historic and recent collections of *Ameiurus serracanthus* and *Ameiurus brunneus* in Florida

The Florida Fish and Wildlife Commission (FWC) recently completed three studies investigating the status of *Ameiurus serracanthus* (spotted bullhead) and *Ameiurus brunneus* (snail bullhead) in the state of Florida. A considerable amount of electrofishing effort was expended during these studies, after which FWC collection data were compared with historic records. For certain Florida drainages where one or both of the species was historically collected, either there was little evidence of the presence of the species, or abundances were

unexpectedly low. In one drainage, low numbers of both *Ameiurus* species corresponded to the high abundance of *Pylodictis olivaris* (flathead catfish), and in another, habitat changes in recent decades may have limited suitable habitats within the native range of *A. brunneus* in the state. Although *A. brunneus* ranges throughout several southeastern U.S. states, it may be prudent to conduct additional studies on the isolated St. Johns River population of the species, and thereafter to determine whether the species should be provided protective status in Florida. Since the range of *A. serracanthus* is much more restricted in the southeastern U.S., populations should be periodically monitored to detect any changes in range or abundance. For both species, detailed ecological and reproductive data are sparse.

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Activity patterns, distribution and population structure of the yellow stingray, *Urobatis jamaicensis* in Southeast Florida.

The yellow stingray, *Urobatis jamaicensis* is a commonly observed elasmobranch in coastal waters of Southeast Florida. Despite their frequent occurrence the ecology of yellow stingrays remains poorly understood. Acoustic tracking and extensive visual point counts were conducted to determine the short-term movements, seasonal distribution and population structure of yellow stingrays in Broward County, Florida. Diel activity patterns displayed intermittent movements throughout the day; however, nocturnal movements exhibited a significant increase in both rates of movement and space utilization. Total daily movements were confined to relatively small areas (mean = 21,403m² +/- 10,696 SEM) and demonstrated strong site fixity, which implies a possible display of home ranging behavior. However, intermittent tracking across several days indicates that yellow stingrays may not utilize their full range on a daily basis. Landscape topography demonstrated considerable influence on the space utilization of stingrays and movements varied with proximity to the reef edge/sand interface. Yellow stingrays remained permanent residents within the study site with no indication of varying inshore/offshore seasonal distribution. Apparent gender segregation was noted during spring months (March, April, May) with females dominating the inshore region 20F:8M. Average individual size of the population was 333mm total length (TL), with females dominating the larger size classes (>350mm TL). The occurrence of increased numbers of intermediate size classes (250-299mm to 300-349mm TL) on the offshore reef suggests a potential ontogenetic shift to deeper water or range expansion. Field observations of gravid females occurred throughout the year, however, the annual reproductive cycle remains unclear. Reports of a 3-month gestation rate and observed peaks in non-gravid females during the months of February and October suggest two separate ovulatory cycles. Preliminary results from an ongoing reproductive study further indicate a biannual cycle with an undetermined number of broods produced per female each year.

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Trying again two centuries later: an essay on the various species of sawfish (Chondrichthyes, Pristiformes)

The sawfishes, family Pristidae, is comprised of seven nominal species: *Anoxypristis cuspidata*, *Pristis pectinata*, *P. zijsron*, *P. clavata*, *P. perotteti*, *P. microdon* and *P. pristis*. However, due to considerable taxonomic confusion this number may in fact vary between four and ten. Among the reasons for this taxonomic disarray is that many of the original species descriptions were extremely abbreviated, and in some cases not even based on specimens, or based only on isolated anatomical parts; only two of the six type specimens are available for examination today; poor representation of specimens in collections, which mostly consist of dried rostra or very young specimens; and scarcity of these animals in their natural habitat due to overfishing. In the present study we reviewed sawfish taxonomy based on evidence from (1) morphological (external morphometric and meristic characters) and molecular data (DNA sequence from one mitochondrial gene, NADH-2) of representative specimens, (2) museum records and historical specimens, (3) distributional information derived from archaeological remains and anthropological artifacts and (4) review of the primary literature. Inferences based on our results are discussed in the context of sawfish diversity, geographical distribution and historical taxonomy.

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Home range and activity patterns of eastern hognose snakes, *Heterodon platyrhinos*, in the Central Pine Barrens of Long Island, New York

The Eastern Hognose Snake, *Heterodon platyrhinos*, was historically abundant on Long Island, New York. However, pressures associated with habitat loss, fragmentation, and other anthropogenic disturbances incurred catastrophic impacts upon populations over the past several decades. By the end of the twentieth century, most local experts believed the species to be completely extirpated from Long Island. Then, in 2002, five observations of *H. platyrhinos* were made at the Brookhaven National Laboratory (BNL), a 2,130-ha facility located in the east-central Pine Barrens region of the island. These observations spurred biologists from BNL and the U.S. Fish & Wildlife Service to initiate an extensive program aimed at studying the ecology and habitat use of hognose snakes at BNL while also trying to identify any other remnant island populations via communications with local naturalists and requests to the general public through the local media. To better understand the behavioral ecology of *H. platyrhinos* we used radio telemetry to track movements of 12 snakes (3 males: 9 females) and mapped all locations using GPS and GIS. From three years of tracking we have obtained data on movement patterns, home range sizes, and habitat usage as well as a number of other ecological attributes. Our results confirm that home ranges of individual hognose snakes are extensive (> 30 ha in

some cases) and that movement patterns show trends regarding daily and yearly cycles. Estimates of home range sizes are needed to determine the amount of land and types of landscapes necessary to manage viable populations of *H. platyrhinos*. As destructive habitat modifications continue, our research can be used as a foundation for protecting *H. platyrhinos* in Pine Barrens habitats of the northeastern U.S.

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Role of contaminants in the decline of amphibians in the Sierra Nevada Mountains, California, USA

Several species of amphibians are experiencing severe population declines in of the Sierra Nevada Mountains of California. This is occurring in some of the largest wilderness areas including Yosemite, Kings Canyon, and Sequoia National Parks. Some species are absent from much of their original range. There is strong evidence that prevailing westerly winds transport airborne pesticides from the Central Valley of California into the mountains where they are deposited with rain or snow. We have several lines of observational and experimental evidence that provide evidence that amphibian declines in the Sierra Nevada are caused by pesticides. 1) Some insecticides inhibit cholinesterase activity not only in insects, but in non-target vertebrates as well. Cholinesterase is an enzyme essential for proper nerve function, and depressed cholinesterase activity inhibits the ability to jump, swim, and breathe. We examined *Hyla regilla* and found that tadpoles from Yosemite and Sequoia had reduced levels of cholinesterase compared to coastal sites. 2) Laboratory experiments using two native frogs, *Hyla regilla* and *Rana boylei*, have shown that the pesticides applied in the greatest quantity (kg of active ingredient) in the Central Valley (chlorpyrifos and endosulfan) have significant negative effects on survival, percent survival to metamorphosis, time to metamorphosis, and size at metamorphosis. Endosulfan was more toxic than chlorpyrifos, and *R. boylei* were more sensitive than *Hyla regilla*. 3) We have measured levels of contaminants in *Hyla regilla* adults and tadpoles, as well as in air, snow, sediment, and pond water in the Sierra Nevada, and coastal control sites. Environmental concentrations of chlorpyrifos and endosulfan are similar to those that cause reduced survival in laboratory experiments. Our work demonstrates that environmentally realistic concentrations of commonly used pesticides can have an impact on native amphibians in the Sierra Nevada Mountains of California.

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Ultraviolet exposure and vitamin D synthesis in a sun-dwelling and a shade-dwelling species of *Anolis*

We compared the natural UVB exposure, dietary vitamin D and skin-generated vitamin D synthesis for two species of Jamaican anoles. The more shade-tolerant and thermal-conforming *Anolis lineotopus merope*, rarely exposed to full sun, experienced less UVB irradiation in its shady environment than the more heliophilic and thermophilic *Anolis sagrei*, which frequently basked in full sun during the morning hours (0800-1100). Both species obtained detectable levels of vitamin D₃ in their diet but the heliophilic *A. sagrei* obtained more. To compensate for less availability of UVB and dietary vitamin D, the skin of *A. l. merope* seems to have acquired a greater sensitivity than that of *A. sagrei* regarding UVB-induced vitamin D₃ photobiosynthesis. We assessed this by observing a greater conversion of provitamin D to photoproducts in the skin when exposed to UVB from a sunlamp. The reduced skin sensitivity of *A. sagrei* regarding vitamin D photobiosynthesis may reflect a correlated response associated with less need for vitamin D photobiosynthesis and greater need for UVB screening capacity as an adaptation to a higher UVB-damaging environment. However, the possibility that adaptations for photobiosynthesis of vitamin D and for protection from skin damage could involve independent mechanisms needs investigation. Also, the ability to behaviorally regulate UVB exposure, as shown for the panther chameleon, would benefit both species of *Anolis* and should be investigated.

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Natural UVB exposure and UVB/Vitamin D photoregulation in *Anolis sagrei* and *Anolis lineotopus merope*

Exposure to ultraviolet-B radiation (290-315 nm/cm², UVB) has both negative and positive consequences. UVB can cause cell, tissue and DNA damage but is necessary for the endogenous synthesis of Vitamin D₃, a nutrient vital for calcium-phosphorus regulation. Previous study on diurnal lizards in captivity has shown that UVB/Vitamin D₃ photobiosynthesis is necessary for vitamin D health and that females and juveniles have higher UVB exposure requirements than adult males. Furthermore, among species, vitamin D₃ photobiosynthetic potential of the skin is correlated inversely with natural maximum UVB exposure, suggesting a tradeoff between UVB damage protection and vitamin D

photobiosynthetic potential. In a combined laboratory and field study on the Jamaican anole *Anolis lineotopus*, a native shade-dwelling species, and *Anolis sagrei*, an introduced sun-dwelling species, we demonstrated greater natural UVB exposure of female-sized animals (adult females and juvenile males) than adult males with similar body-substrate temperatures. Furthermore, we demonstrated that individuals of *Anolis sagrei* expose themselves voluntarily to UVB significantly more often in a laboratory gradient when dietary vitamin D3 (an alternate vitamin D source) was low. The latter suggests the ability for behavioral vitamin D photoregulation, which has been previously documented in the Panther Chameleon.

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Aglyptorhynchus, an extinct billfish (Perciformes: Xiphioidei: Palaeorhynchidae) with a mobile rostrum and head

Aglyptorhynchus Casier 1966, (circa 10 species; early Eocene-middle Miocene; Belgium, England, U.S.A.) differs from other teleost fishes by having a ball and socket joint between the occipital condyle and first vertebra, and differs from other billfishes by having a large condyle on the postero-dorsal border of the maxilla for articulation with the ethmoid. In addition, the posterior end of the maxilla is expanded into a large, ventral flange that probably had a ligamentous attachment to the angular. Presumably, the rostrum moved dorsally as a unit about the maxillo-ethmoid articulation to increase the gape when the lower jaw was depressed, and the joint between the skull and first vertebra allowed the head to move independent of the body. Because body shape and number of fins is unknown, and interpretations of the paleoenvironment of the fossil deposits are equivocal, how *Aglyptorhynchus* exploited its unusual feeding apparatus is speculative.

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Support for placement of snakes within Anguimorpha from tongue ultrastructure

The phylogenetic relationship of snakes within squamates has been the subject of historical debate, and is of renewed interest. The placement of snakes within Anguimorpha is a decades old hypothesis, based on morphology, which has had recent cladistic support. However, there have been a number of alternative phylogenetic hypotheses put forward including suggestions that snakes are related to amphisbaenians, dibamids, iguanians, or that they are the sister group to all other squamates. Recent molecular phylogenies, in particular, have failed to support a snake-anguimorph relationship. Our work on the ultrastructure of squamate tongues has revealed that snakes possess a character that is unique to anguimorphs. This character is the 'microfacet' which is a small (0.1-10 μ m diameter) lipid filled protrusion on the epithelial surface of the tines of the

tongue. Detailed similarity of these structures in snakes, varanids, helodermatids and anguids strongly supports their homology, lending further support to the hypothesis that snakes lie within the Anguimorpha.

***FISK, AARON; STRID, ANNA; MATTIASSON, KARIN;
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Everything under the sun: Contaminants in the Greenland shark

Anthropogenic contaminants are a continuing concern for marine life, particularly higher trophic level organisms that can accumulate high levels due to biomagnification. Although many sharks feed at or near the top of food webs, we know very little about levels and effects of contaminants in these fish. The Greenland shark (*Somniosus microcephalus*) is a large, long-lived, cold water species that feeds throughout the marine food web and thus has the potential to have high concentrations and a wide variety of contaminants. Samples of liver were collected from Greenland sharks from Iceland and the Canadian Arctic to examine a large list of contaminants and their metabolites in this species. Levels of legacy organochlorine contaminants (e.g., PCBs, DDT, chlordanes) were very high in the shark from both Iceland and the Canadian arctic, and were similar to other higher trophic level arctic organisms. These sharks were also found to contain metabolites of PCBs and DDT, dioxins, and heavy metals, as well as new contaminants of interest brominated (including a number that are believed to be naturally produced) and fluorinated compounds. This study represents the most comprehensive examination of contaminants in an elasmobranch species to date. The contaminant pattern in the Greenland shark is very unique and raises questions about the source of these contaminants, levels of contaminants in sharks, and the biotransformation capacity of elasmobranchs.

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Introduction of *Tupinambis teguixin* to San Andrés Colombia, with comments on changes in the herpetofauna of San Andrés and Old Providence since 1600

The recent introduction of *Tupinambis teguixin* (common tegu lizard) to the Caribbean island of San Andrés, Colombia poses a threat to biodiversity and society throughout the region. Tegus were introduced in 1984 when a shipment of animals destined for the pet trade was detained, and juvenile tegus were released. These large (up to 3 kg), lizards are now common throughout the

island, and have become a nuisance to locals because they prey on chickens and pets. Researchers are only beginning to address the social, economic, and ecological impacts of the tegu lizard invasion. One herp species possibly impacted by tegus is the endemic snake, *Coniophanes andresensis*. After a recent search lasting several months, only one individual was collected. It is plausible that *C. andresensis* is vulnerable to predation by tegus, and its status should be further investigated. Tegus are omnivorous, habitat generalists, and large enough to avoid many predators. These life history traits may facilitate their establishment throughout Mesoamerica and elsewhere. Other anthropogenic species introductions have occurred since 1600 on San Andrés and Old Providence, located 90km north of San Andrés. *Iguana iguana* is established on both islands, and *Geochelone carbonaria* is established on Old Providence. Since the 1970s four other reptiles have become established in the archipelago. *Tretioscincus bifasciatus* is well established on Old Providence. *Caiman crocodilus* was introduced with the same shipment of pets in 1984, and is established in the freshwater lagoon on San Andrés. *Gonatodes albogularis* and *Hemidactylus frenatus* are established on both islands. The introduction of tegus to San Andrés should serve as a severe warning that this predaceous lizard could become established on other islands, with unforeseen impacts.

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The radial muscle: A new chapter in shark tails

The swimming kinematics and hydrodynamics of heterocercal tails in elasmobranchs have been the focus of a number of recent studies. However, the locomotor functions of the internal morphological structures of the heterocercal tail remain unexplored. In this study we examine the morphology and function of the radial muscle or radialis during swimming in the spiny dogfish *Squalus acanthias*. The radialis consists entirely of red muscle fibers and is located ventral to the segmented axial myomeres in the most distal region of the caudal fin, originating on the ventral processes of the vertebral column and inserting along the horizontal septum. Individual muscle fibers are arranged dorsoposteriorly at angles ranging from 14 to 88 degrees relative to the vertebral column. The muscle fibers of the radialis share a similar fiber orientation and lie in close association with the deepest layer of the subdermal connective tissue sheets. Electrical stimulation of the radialis in anesthetized sharks results in visible movement of the ceratotrichia of the dorsal lobe of the caudal fin. Using sonomicrometry, we found that muscle fibers shortened by <1% of their resting length during stimulated contractions. Finally, we combined bilateral electromyography of the radialis with simultaneous video to determine the point of activation of the radialis within the tailbeat cycle. Our results indicate that the radialis is active immediately after maximum lateral excursion of the caudal fin to the ipsilateral side. We also find that the activity patterns of the radialis on the right and left side of the body are approximately 180 degrees out of phase. Morphology and motor patterns of the radialis suggest that this muscle is acting as postural reinforcement, and controlling the orientation of the dorsal lobe of the caudal fin during steady swimming. AES GRUBER

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Evaluation of visual encounter surveys as an accurate monitoring method in a rare salamander species

Many amphibian species are imperiled. Effective monitoring of population size is critically important for endemic species with specialized habitat requirements so that timely remedial steps can be taken when declines are detected. We initiated a monitoring study of the endemic plethodontid salamander, *Plethodon punctatus*, which is generally found in talus habitats over 1000 m in elevation. We tested the congruence of nighttime visual encounter surveys (VES) and mark-recapture estimates of population size. VES was an accurate index of relative population size when two different habitats were surveyed. Sites on the eastern and western sides of Shenandoah Mountain were surveyed, and both methods estimated that population size on the west was approximately twice as high as that on the east. Individuals of this species exhibited a high degree of site fidelity. Cover object searches for species in talus habitats are expected to be of limited value, and we conclude that nighttime visual encounter surveys are most effective for population size monitoring of *P. punctatus* and other species that live in talus.

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The macroecology of marine cleaning mutualisms

Cleaning mutualisms are widespread among marine animals. Despite a growing literature, the determinants of species interactions in this kind of mutualism are not well understood. Several factors could influence the frequency of interactions among cleaners and client fish species at the community level. First, body size can partly determine parasite load and parasite species composition, so that larger hosts provide more opportunity for cleaning than smaller bodied species; this effect would result in a positive relationship between host body size and cleaning frequency. Second, cleaners could interact more frequently with abundant fish than with rare ones, resulting in a positive relationship between client species abundance and the frequency with which they are cleaned. Finally, both abundance and/or body size relationships with cleaning frequency could be modulated by biological characteristics of the clients (e.g. social behavior, trophic habits) and cleaning 'facultativeness'. We compiled a database on cleaning interaction frequency between 10 ubiquitous fish and one shrimp cleaner species and their 204 client fish species at 8 locations including the Caribbean, Brazil, the Mediterranean and Australia, to evaluate macroecological determinants of these interactions. Using meta-analytical techniques, we found a

strong, positive relationship between client cleaning frequency and the abundance of clients. This effect was modulated by client trophic group, social behavior and spatial distribution in the water column. Conversely, body size showed only a weak effect on cleaning frequency. Finally, we found no support for differences in cleaning frequency between obligate and facultative cleaner species in relation to their client's characteristics.

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Morphological and molecular variation of the Inland Silverside, *Menidia beryllina*

Current literature treats the Inland Silverside, *Menidia beryllina* (Cope, 1869), as a single species. However, a recent study detected two distinct groups based on meristic and morphometric characters which suggested that *M. beryllina* may actually represent two species, *M. beryllina* and *M. audens* (Hay, 1882). Although examined extensively over the past thirty years, much debate still exists over the current status of this species group. The current study examined body shape variation within this group using geometric morphometric techniques. Principal components analysis of morphometric characters yielded two significantly ($p < 0.05$) different axes that combined accounted for 56% of the total variation explained. Principal component and canonical variates analyses of morphometric data showed a continuum between putative *M. audens* and *M. beryllina* that could be interpreted as either plasticity within a single species or introgression between two species. However, there was no apparent clinal relationship in morphometry between the two forms. Tissue samples of 74 individuals have been collected from the Lower Mississippi River and brackish estuaries in South Louisiana. We are using mitochondrial DNA sequences of the ND2 gene to determine how morphological differences correlate with molecular divergence while exploring the genetic and morphometric composition of the species. Preliminary results of the molecular analysis will be presented with updated morphometric results.

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Preliminary phylogeography of the ringneck snake *Diadophis punctatus*

The ringneck snake (*Diadophis punctatus*) is a common yet secretive monotypic North American colubrid with a transcontinental range extending along both coastlines and throughout the southeastern, southwestern and central United States. Range-wide studies of morphology have resulted in thirteen subspecies based on body size, scutellation and color patterns. Using similar characters, localized studies have demonstrated that four of the thirteen recognized subspecies could be found from populations in Nova Scotia and Kansas, questioning the utility of the diagnostic characters. Molecular data used in

phylogeographic analyses have demonstrated that much of the biodiversity throughout the United States has been underestimated with respect to snakes. This purpose of this study is to examine the phylogeographic patterns of the *D. punctatus* subspecies complex using a combination of nuclear and mitochondrial genes. Utilizing both mitochondrial and nuclear data will aid in detecting if subspecies represent evolutionary lineages. Additionally it is possible that there are undetected lineages that are associated with geographical areas. Preliminary results suggest that the lineage diversity of *Diadophis* in the Southeastern and Central United States has been underestimated whereas the lineages of *Diadophis* from the west coast and Southwestern United States have been overestimated if subspecies were considered to be lineages. By analyzing multiple data sets both individually and combined, this study will provide a better understanding of the representative biodiversity for *D. punctatus* throughout the US. The hypotheses generated from analyses of these genes can then be used to serve as a backbone for determining useful morphological characters for identification of lineages, clarifying species boundaries, and comprehending the geological and environmental factors that have shaped the evolution of *Diadophis*.

***FONTENOT, BRIAN E.; FRANKLIN, CARL; MEIK, JESSE M.**

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Identification of an apparent natural hybrid between *Crotalus atrox* and *Crotalus horridus* using electron microscopy

The rattlesnakes *Crotalus atrox* and *Crotalus horridus* are distributed throughout large portions of North America with *C. atrox* occurring primarily in the central and southwestern regions, and *C. horridus* occurring primarily in the eastern and central regions. Both species occur in sympatry in small portions of their range. Hybridization between congeneric rattlesnakes has rarely been documented. We present evidence of an apparent natural hybrid between the rattlesnakes *C. atrox* and *C. horridus* based on analysis of morphological characters, including details of dorsal scale microdermatoglyphics, scalation, and color pattern. The individual displays characteristics intermediate between *C. atrox* and *C. horridus* and previous studies have used novel morphological characteristics and scale microstructure as evidence to identify natural hybrids between rattlesnakes.

FONTENOT, CLIFF

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Underwater pupillary constriction and the lack of a pupillary response to light in the garter snakes (*Thamnophis*)

Snakes lack a ciliary muscle. Instead, their method of vision accommodation is lens movement via pupillary constriction. However, this suggests that snakes may not be able to regulate light input because the iris muscle is involved in lens movement. An especially intriguing case is with the Garter Snakes (*Thamnophis*), because semi-aquatic animals are faced with the difficulty of seeing clearly in two different media. Moving from air to underwater imposes substantial defocus due to the difference in refractive indices. In particular, several *Thamnophis*

species have been shown to circumvent this problem by constricting their pupils, thereby increasing the depth of field, albeit at the expense of light input to the retina. Thus, *Thamnophis* is a good model to test the role of the pupil in light regulation because they regularly experience extreme pupillary constriction related to focusing. To test the effect of light and medium on pupillary constriction, I exposed individuals of *T. atratus*, *T. hammondi*, and *T. sirtalis* to nine different light levels in air, then repeated the procedure with the snakes submerged underwater. Each species tested showed significant pupillary constriction underwater. However, none showed significant pupillary constriction in response to changing light levels in air nor underwater, nor was there a difference in slope among media. The results suggest that these semi-aquatic snakes are indeed using pupillary constriction to enhance underwater vision. However, the lack of difference in slope among media suggests that it is not the degree of pupillary constriction that controls the pupil's ability to respond to light. Instead, the pupil may be unable to regulate light input because of the general mechanics of the vision system.

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Ophiophagous snakes can trail both sexes of a prey species

Snakes produce pheromone trails that are used to draw the sexes together during the breeding season and to locate hibernation dens. The trail pheromones are long lasting but apparently only produced by females when they are receptive. Snakes are also known to be able to follow trails of prey species during predatory events. Whether ophiophagous snakes are capable of tracking other species has not been tested but following the pheromone trails of female snakes would be a mechanism for locating prey by such snake-eating snakes. The objective of this study was to determine whether king snakes, *Lampropeltis getula*, could follow trails of either sex or only receptive female corn snakes, *Pantherophis guttata*. Twenty trials of four different tests using eight adult king snakes were conducted in a bottomless Y maze. The tests were of trails placed on butcher paper of receptive female corn snakes against a blank, trails of male corn snakes against a blank, trails of female corn snakes against male corn snakes, and a hexane wash of the shed skins of both male and female corn snakes against a blank. A 1 tailed binomial test assuming the king snake would chose the arm with the trail indicated that king snake did trail corn snakes but did not distinguished between male or female trails. The artificially prepared trail did not illicit trailing. These results are somewhat surprising in that only female snakes are known to produce trail pheromones and suggest that some other skin chemicals are being deposited.

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Factors influencing reproductive traits in western ribbon snakes

The trade-offs between reproductive traits and growth as they relate to environmental variation is one of the most complicated aspects of life-history evolution. One poorly understood aspect of this is how the different timescales over which energy is acquired is involved. For example, yearly variation in reproductive traits of snakes often reflects differences in prey availability both within and among years. Western ribbon snakes (*Thamnophis proximus*) from an east Texas hardwood bottomland offered an opportunity to separate the effects of long-term and short-term energy acquisition. In this floodplain, oxbows and temporary pools fill with nutrients deposited by winter inundations and this translates into significant fish and amphibians prey for ribbon snakes as the pools dry up in the spring and summer. The occurrence and timing of floods are unpredictable and prey availability is very different each year in both time and amount. The reproductive traits of ribbon snakes were studied in three consecutive years (2002 to 2004). Pregnant females were collected in May from the Old Sabine Bottom Wildlife Management Area, Texas. These females were individually housed, placed on either high, low, or zero diets, and fed rana tadpoles and minnows bi-weekly until parturition. Females were measured (SVL) and weighed weekly. After birth, which occurred in late June and early July, offspring were counted, then individually weighed and measured. ANCOVA was used to compare reproductive traits with year and diet effect as treatments and SVL as the covariate. There was significant among year variation in clutch size but not in offspring size. Diet had no effect on either of these traits but did affect female postpartum mass and relative clutch mass. We suggest the difference between years must therefore reflect prey availability from the previous year.

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Geographical and temporal variation in length distributions of six species of shark taken in the bottom longline fishery off the southwestern United States

For any species subject to commercial fishing, changes in size distribution over time may indicate larger population-wide trends such as over-fishing and compensation. Thus, accurate data on catch size are important for assessment of current fishery management strategies. Seasonal changes in size may also indicate sex or size specific aggregation or be reflective of migratory patterns. We present an annual and monthly analyses of fork length (FL) distributions by sex of six coastal commonly targeted shark species in the bottom longline fishery off the southeastern United States. Length-frequency for *Carcharhinus plumbeus*, *C. limbatus*, *C. leucas*, *Sphyrna lewini*, *S. mokarran*, and *Rhizoprionodon terraenovae* were

collected by the Commercial Shark Fishery Observer Program (CSFOP) between 1994 and 2004. Data were analyzed for differences in FL for males and females based on the fishing region, month and year. Significant differences in length frequency distributions were determined over time and between geographic areas. Factors influencing seasonal and regional patterns as well as long-term shifts in size classes will be discussed.

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Egg recognition by desmognathine salamanders: A comprehensive re-examination

We conducted a comparative investigation of egg recognition by four species of desmognathine salamanders: the Seepage Salamander (*Desmognathus aeneus*), the Santeetlah Salamander (*D. santeetlah*), the Ocoee Salamander (*D. ocoee*) and the Northern Dusky Salamander (*D. fuscus*). Two-choice behavioral tests revealed that female salamanders of all four species move randomly in the absence of eggs and prefer their own eggs to a filter paper blank. When given a choice of their own eggs over those of a conspecific clutch of the same age, females of all four species spent more time with their own eggs (56-70%), but this preference was significant only for *D. ocoee*. However, when the data for all four species were pooled to increase the sample size, there was a significant preference for *own* eggs. We also conducted tests to determine if egg recognition is innate or learned. Forty-nine *D. ocoee* females were given a choice of their own eggs and those of a conspecific female immediately after egg deposition. Their eggs were then switched and the same choice-test was conducted after the females had been with the surrogate clutch for 21 days. The mean time spent with *own* eggs decreased between tests and 11 females that had spent >80% of the first trial with their *own* eggs exhibited a preference for the *surrogate* clutch during the retesting period. These results suggest a learned component to egg recognition. We attempted to extract behaviorally active chemical compounds from the mucopolysaccharide membranes of salamander egg masses. Biological extraction of polar and non-polar compounds from the eggs of three species failed to elicit female attraction. The existence of membrane-bound chemical signals remains unverified.

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Early life history, growth, and reproduction of weedy sea dragons, *Phyllopteryx taeniolatus*

Weedy sea dragons, *Phyllopteryx taeniolatus*, are an endemic and protected species in southern Australia; however, a detailed description of their life history has not been described. The developmental stages, somatic and reproductive growth, and the reproductive behavior of weedy sea dragons were described using a captive population. Weedy sea dragon development was described based on dominant morphological characters and categorized into 4 periods: incubation, larval, juvenile, and subadult. The von Bertalanffy growth

parameters generated from the length-at-age data of weedy sea dragons of known age were $L_{inf} = 285 \pm 3$ mm TL and $k = 2.20 \pm 0.05$ yr⁻¹. A gonosomatic index was used to assess reproductive growth, which was determined to be very low (<0.003%). Weedy sea dragon courtship involved a tail curling behavior, where males approach and curl their tails away from females. Females also curl their tails away from the male. Breeding occurs when the pair swims upward in the water column with the female transferring eggs to the male's brood patch. Female weedy sea dragons ranging from 251 to 322 mm TL ovulated an average of 110 eggs per spawning event and male weedy sea dragons ranging from 310 to 328 mm TL successfully incubated an average of 91 eggs per egg transfer. Male brood patch size limited the number of eggs that could be accommodated by the male; therefore, limiting the reproductive success of the pair. However, since females have the ability to ovulate more than once in a breeding season, they have the capacity to mate with more than one male per season increasing their reproductive success. In addition to improving our understanding of the life history of weedy sea dragons, this information can be used to estimate demographic parameters and assist in better classifying this species' threatened status. **STOYE GENERAL ICHTHYOLOGY**

FORSON, DIANE; *STORFER, ANDREW

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Effects of atrazine and iridovirus on the long-toed salamander, *Ambystoma macrodactylum*

Environmental contaminants and emerging infectious diseases are implicated as factors contributing to global amphibian declines. However, few studies have tested the interaction of these factors. We examined the effects of atrazine and an iridovirus on the long-toed salamander (*Ambystoma macrodactylum*). *Ambystoma tigrinum virus* (ATV) is an iridovirus responsible for tiger salamander epizootics throughout the western cordillera of North America. Atrazine is the most widely used herbicide in the world and a known endocrine disruptor. We exposed larvae to ATV (0 or 103.5 plaque forming units/mL) and sublethal, but ecologically-relevant, concentrations of atrazine (0, 1.84, 18.4, and 184 ug/L) in a 4x2 factorial design for thirty days. We tested the effects of atrazine and virus on time to and weight and snout-vent length (SVL) at metamorphosis, as well as on rates of mortality and viral infectivity. We confirmed ATV transmission to *A. macrodactylum* via PCR, but infection rates were lower than expected, consistent with theory predicting lower pathogen transmission to non-native hosts. No sublethal infections were found. Therefore, long-toed salamander populations could be affected if ATV introduced into their habitat but are unlikely to serve as reservoirs due to short infection duration in lethally infected animals. Larvae exposed to both atrazine and ATV had lower levels of mortality/ infectivity than larvae exposed to virus alone, particularly at 1.84 and 18.4 ug/L, suggesting atrazine may compromise virus efficacy. Atrazine accelerated metamorphosis and reduced mass and SVL at metamorphosis at 184 ug/L. Our study suggests low to moderate levels of atrazine may ameliorate the effects of ATV on long-toed salamanders in the laboratory, while higher doses may reduce fitness by altering life history traits such that animals are smaller and weigh less at metamorphosis.

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Low genetic variability in *Sceloporus orcutti* using cross species amplification of microsatellite loci from *S. occidentalis*.

Microsatellite DNA analysis can be used to determine kinship, and assign parentage within populations. Cross use of microsatellite primers among related species, typically within a genus, is not an uncommon approach in such studies. However, variability in microsatellite loci may not be conserved between species, which is problematic for kinship and parentage analysis. I attempted to use 18 microsatellite primers sets, developed for *Sceloporus occidentalis* (*undulatus* group), to assign parentage and determine kinships within a population of *S. orcutti* (*magister* group). I successfully amplified 16 of the 18 loci, but 14 were definitively monomorphic. It has been suggested that reduced variability should be expected from cross-species amplification between different species groups within *Sceloporus*, and that high frequencies of monomorphism are a result of microsatellites no longer being present in the target species. In my comparison of the original microsatellite locus sequences in *S. occidentalis* with *S. orcutti* sequences, I found that 4 of 5 of these sequences contained the microsatellite repeats, although the flanking regions varied in conservation of nucleotide sequence from 76.7-97.5%. I also applied the microsatellite primers to 4 other *Sceloporus* species from 2 additional species groups, as well as 2 additional genera, and found polymorphisms. The occurrence of polymorphisms across species groups and related genera for the *S. occidentalis* primers suggests another reason for the high levels of monomorphism in *S. orcutti*. The lack of allelic variability at the amplified microsatellite loci in *S. orcutti* may be a result of either small actual population size, low effective population size due to the breeding system, or fluctuating population size through time. Additional microsatellite loci from either *S. occidentalis* or another species and genotyping of individuals throughout the range of *S. orcutti* would be the next step in determining the cause of high levels of monomorphism in this species. **SSAR SEIBERT**
EVOLUTION/SYSTEMATICS

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First case of ranavirus-associated morbidity and mortality in natural populations of a South American amphibian: Occurrence and effects

We report the first case of ranaviral disease in a South American amphibian, the endangered Patagonian frog *Atelognathus patagonicus* from Argentina. Clinical signs of the disease are presented in both late-stage tadpoles (hemorrhages in the tail, abdomen, back legs, and throat; swollen, greatly distended abdomen from accumulation of fluid in the body cavity; frequent excretion of bloody mucus from the vent; impaired swimming ability and proper buoyancy; labored

respiration; frequent death upon capture) and recent metamorphs (intense redness of the venter, thighs, and abdomen; white blotches on the dorsum; edema on the throat; impaired locomotion; frequent death upon capture). In both life forms, hemorrhages in various internal hematopoietic organs suggested a systemic infection. We collected symptomatic and asymptomatic *A. patagonicus* frogs and tadpoles from four small lakes and analyzed tissues for ranavirus and the chytrid fungus *Batrachochytrium dendrobatidis* using PCR amplification of pathogen DNA. Twenty-five of the 32 specimens tested positive for ranavirus major capsid protein. In addition, one sample (three pooled animals) from one lake tested positive for *B. dendrobatidis*. The clinical signs, which have reoccurred each year since at least 2001, are attributed to the ranavirus. Infection by *B. dendrobatidis*, which is only the second case reported in Argentina, may be non-pathogenic in this species. In laboratory trials symptomatic tadpoles reacted less actively to a tactile stimulus, swam slower, and were more susceptible to predation by an invasive fish that has been introduced into the frog's range.

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**Morphometric minefields - towards a measurement standard for
cartilaginous fishes**

Size measurements are crucial for studies on the growth, maturation, maximum size, and population structure of cartilaginous fishes. However different researchers may use a variety of measurement techniques even when working on the same species. Accurate comparison of results among studies (e.g. time series of measurements on the same population, cross-population comparisons) is only possible if (a) the measurement technique used is adequately defined, and (b) in situations where different techniques are used, a conversion equation can be derived. These conditions have not always been met, leading to invalid comparisons and incorrect conclusions. Using data for shortfin mako shark (*Isurus oxyrinchus*) and an Antarctic skate (*Amblyraja georgiana*), I explore the morphometric relationships among different measurement techniques and the complications presented by allometric growth. The pros and cons of various body measurements on sharks, skates and chimaeras are discussed. Suggestions are provided for selecting an appropriate measurement technique, recording additional measurements on a subsample of the fish to develop conversion regression relationships, and the establishment of an international database of conversion equations.

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The movements and habitat selection of juvenile lemon sharks, *Negaprion brevirostris*, in Bimini, Bahamas over a spatiotemporal scale

We are studying a population of nursery-bound juvenile lemon sharks at Bimini, Bahamas using both manual and automated tracking to answer questions about movement patterns and habitat selection within two primary nursery areas. To date, 48 nursery-bound and 3 non-nursery bound juvenile lemon sharks have been tracked both continuously and intermittently. Seven of these sharks have been in the study for longer than one year. Research questions being investigated include: Do lemon sharks exhibit habitat selection within the primary nursery areas; do environmental factors affect the movements of juvenile sharks; are movements within the nursery correlated with areas of low predation risk and/or high prey availability; does time of day, season, age of shark, or site affect either activity patterns or habitat preference; is the shift from primary to secondary nursery area gradual; is there immigration or emigration by juvenile sharks between primary nursery areas? Answers to these questions will help define the role of nursery grounds in the early life history and evolution of lemon sharks. Initial results suggest that juvenile lemon sharks have clearly defined home ranges with a strong correlation between the size of the shark and size of the home range. The size of the 95% kernel home range averages 47.7 hectares in the South Bimini nursery and 90.7 hectares in the North Sound nursery. Preliminary analyses of the data indicate that sharks disproportionately use areas within the nursery with 91% of all locations being obtained within 200 meters of the shoreline signaling some type of habitat selection. Tracking data support the hypothesis that there is essentially no emigration of lemon sharks from their natal nursery area during the first three years of life. We will discuss the results of data from all 51 sharks investigated over the past 28 months.

***FREEMAN, ALASTAIR B.; FREEMAN, AMANDA N. D.; KROCKENBERGER, ANDREW**

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Predators on the prowl: How does Australia's largest snake survive in a fragmented landscape?

The Amethystine python (*Morelia kinghorni*) is the largest predator in rainforests on the Atherton Tableland in far north Queensland, a region that has undergone severe habitat loss and fragmentation. Surprisingly little is known of the ecology of Amethystine pythons in the wild or of how they respond to habitat fragmentation although anecdotal evidence suggests that these large pythons do not survive in small rainforest remnants. Preliminary results from six months

radio-tracking of Amethystine pythons in a habitat mosaic comprised of primary rainforest, varying stages of regrowth and pasture show that this species occupies home ranges up to 120ha with movements up to 800m recorded within a 24 hour period. Primary rainforest habitat was favoured, at least in the coolest part of the year, when radio-tracked Amethystine pythons remained in Staghorn (*Platynerium* spp.) and Basket ferns (*Drynaria* spp.) in the rainforest canopy for periods as long as four weeks. Densities of such epiphytes may be reduced in remnant and regrowth rainforests, which may be a factor limiting the distribution of Amethystine pythons on the Atherton Tablelands.

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Habitat use in two species of tropical boid using roadkill and incidental data

The study of habitat use in snakes is often difficult without access to expensive radio telemetry equipment. However, in many situations, a ready and cheap source of data is available in the form of roadkill specimens and, to a lesser degree, incidental observations. Over three and a half years this kind of data was collected for two species of tropical boid (*Morelia spilota* and *Morelia kinghorni*) on the Atherton Tablelands in North Queensland. The Atherton Tablelands is a mid-elevation plateau situated in the Wet Tropics of North Queensland. Today the area is a mosaic of farmland and small towns interspersed with upland rainforest fragments ranging in size from 1 to 600 hectares. Large areas of continuous forest are confined to dissected hill slopes that surround the Tablelands. Data from this study indicate that there are striking differences in the response of these two species to the forest fragmentation that has taken place in this area. While *M. spilota* appeared to be common and widespread, found in a variety of habitats, *M. kinghorni* records were almost entirely confined to forested areas. Surprisingly, the latter species was also absent from some rainforest fragments that appeared to be suitable habitat. The pattern of distribution observed in these two boas was further supported by prey items found in stomach samples collected from road-killed animals. Interestingly the data also showed no correlation between the distribution of "jungle carpets", a subspecies of *M. spilota* that is believed to be confined to rainforest in the Wet Tropics, and rainforest habitat.

FREEMAN, AMANDA N. D.

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Skink community composition in a rainforest restoration site

The use of restored habitat by Australian herpetofauna is very poorly known despite some taxa (notably small skinks, with their specific microhabitat requirements, abundance and ease of capture) being potentially useful indicator

species for monitoring restoration success. The skink community utilising a 1ha rainforest restoration site in far north Queensland, Australia, has been monitored using pit-fall traps since initial planting of the site in March 2002. The garden skink *Lampropholis delicata* continues to be the species most commonly caught in the restoration site three years after establishment. Species characteristic of the rainforest fragment immediately adjacent to the restoration site, such as *Carlia rubrigularis*, *Saproscincus tetradactylus* and *Saproscincus basiliscus*, have yet to recolonise the site despite substantial increase in vegetation cover at the site. Neither the restoration site nor the adjacent rainforest fragment contain skink species such as the prickly forest skink *Gnypetoscincus queenslandiae* and *Glaphyromorphus fuscicaudis* which occur in the endangered complex notophyll vine forest type the restoration site seeks to restore.

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Initial response of wood frogs (*Rana sylvatica*) to experimental manipulation of buffer widths around vernal pools in Maine

Strategies to conserve vernal pool-dependent amphibians emphasize the maintenance of adequate areas (buffers) of terrestrial habitat. However, experimental studies are needed to directly test amphibian population response to buffers. During fall/winter of 2003-2004, we experimentally manipulated the width of terrestrial buffer zones surrounding 12 vernal pools in a managed forest in central Maine. Buffer width treatments were 30 m or 100 m forest buffer surrounded by a 100 m clearcut, or no cut (control), in a spatially blocked design with 4 replicates. We encircled pools with drift fences and monitored movement in and out of pools from April through November, 2004 with pitfall traps. We sexed and aged (adult/juvenile/metamorph) individuals and measured SVL and mass. We radio-tracked 19 wood frogs (*Rana sylvatica*) to determine movement, home range, and microhabitat use. A total of 2020 adult wood frogs (N females = 690, N males = 1330) came into the pools. The mean snout-vent length (SVL) was 45.72 mm (females = 48.84; males = 42.60), and the mean mass was 10.05 g (females = 11.65; males = 8.45). Metamorph production was highly variable among pools (range 0 - 526). Mean SVL of metamorphs was 18.12 mm (N = 1421). We radiotracked wood frogs for an average of 41 days (range 3 - 112); average wood frog dispersal distance from pools was 198 m (range 0 - 349), for individuals tracked longer than 5 days. Several frogs (N = 4) remained near the breeding pool during the entire tracking period.

***FRIEBELE, ELAINE; SWARTH, CHRISTOPHER W.**

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Potential factors determining hatchling emergence patterns in red-bellied turtles (*Pseudemys rubriventris*)

Overwintering in the nest by turtle hatchlings is a strategy that probably enhances survival, but the factors that determine fall versus spring emergence are not well understood. From 1998 to 2002, we studied red-bellied turtle

hatchling emergence from 31 natural nests. Hatchlings in 16 nests overwintered and emerged in the spring, while hatchlings in 10 nests emerged in the fall. Five nests exhibited a mixed emergence pattern, wherein some hatchlings emerged in the fall and others in the spring. In all, 124 hatchlings (44%) emerged in the fall, and 157 hatchlings (56%) overwintered. We investigated factors that could influence the timing of emergence. Our results suggest that hatchling emergence season is not genetically predetermined. Hatchlings in nests deposited by the same female ($n = 2$) did not exhibit a consistent emergence pattern: hatchlings from some nests emerged in the fall, and others emerged in the spring. We found no significant relationship between oviposition date and emergence season. We tested the hypothesis that weather during the incubation period influences hatchling emergence season. Neither nest temperature nor rainfall during the incubation period significantly affected emergence season. When precipitation occurred during rising air temperatures in the spring, hatchlings emerged from one-third to one-half of the existing nests. Almost all spring nest emergence occurred as air temperatures were rising rapidly over several days. Hatchlings also emerged from some nests in the fall during heavy rainfall. We suggest that plasticity in season of emergence may be an adaptation for surviving variable or adverse conditions, although the specific factors that control emergence are not readily apparent.

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All catfish species inventory: 2005 progress report

The All Catfish Species Inventory (ACSI) is a 5-year project funded by the National Science Foundation (DEB-0315963) that started in September 2003. The project's mission is to facilitate the discovery, description and dissemination of knowledge of all catfish species by a global consortium of taxonomists & systematists. Since its inception, over 125 new species of catfishes have been described. ACSI is supporting ongoing research at the Co-PI's institutions (ANSP, AUM, CUMV and FLMNH) as well as over 70 researchers from around the world who have applied for funding through this project. The project has supported a variety of activities thus far including: 1) Fieldwork in Argentina, Brazil, Cameroon, Colombia, China, Democratic Republic of Congo, Guyana, India, Indonesia, Mexico, Panama, Peru, Tanzania, Uganda, USA, Venezuela and Zambia to collect new fish specimens, tissues and fossils; 2) Research visits by participants to museums including AMNH, ANSP, AUM, BMNH, CUMV, FLMNH, FMNH, ICN-UN, INHS, LIRP, MHNG, MNHN, MRAC, MLP, MZUSP, NMHN, NMW, SAIAB, TMM and UMMZ; 3) International workshops to stimulate and coordinate research of participants (one on Asian catfishes held in Singapore and another on African catfishes held in South Africa); 4) Digital imaging projects for catfish types specimens at several museums including AMS, ANSP, FMNH, MBUCV, MCNG, MNHN, USNM and ZMUC; 5) Support for publication costs of species descriptions in journals including *Copeia*,

Ichthyological Exploration of Freshwaters, Neotropical Ichthyology, Proceedings of the Academy of Natural Sciences Philadelphia, Proceedings of the Biological Society of Washington, Raffles Bulletin of Zoology and Zootaxa; 6) Production of a Checklist of Catfishes and digitizing of original descriptions of catfish species. Further information on products and results of this project (images, literature, etc.) as well as information on proposal submission is available via the ACSI Website (<http://silurus.acnatsci.org/>).

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The use of caudal thorns as ageing structures on the thorny skate
Amblyraja radiata

Thorny skate (*Amblyraja radiata*) were collected off Greenland during a research cruise in November 2004, primarily to establish whether caudal thorns could be used as effective ageing structures. In total 52 specimens were collected, 28 male, and 24 female, covering the full size range from pre-hatching to fully mature. Age estimates were derived from crystal violet stained sagittal vertebral sections and silver nitrate stained whole caudal thorns. Age bias plots and coefficient of variation indicated that both structures provided similar unbiased and precise age estimates. However thorns generally scored higher on readability scores, which indicated that band resolution was higher on thorns compared to vertebrae. Poor thorn band resolution was however noted on larger specimens, particularly near the periphery where bands were crowded and also near the apex where thorn wear was evident. Vertical transverse sections of silver nitrate stained thorns revealed the underlying band morphologies and growth processes. The study reveals that caudal thorns can be used as effective ageing structures for the thorny skate.

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Sex differences in the hindbrain of two anurans: *Bufo marinus* and *Xenopus laevis*

Sexual differences are apparent in many anuran species. While size dimorphism and other morphological differences are common, the neuroanatomical bases for behavioral sex differences are not as widely documented. Calling for mates is a reproductive behavior that is specific to male anurans in the species, *Bufo marinus* and *Xenopus laevis*. Although females do not call for mates, they are able to produce sound. Their vocalizations, however, differ in frequency and duration from the calls of males. Sexual differences in vocal motor nuclei associated with mate calling in the medulla of *X. laevis* were previously identified by Kelley et al. (1988). I identified sexual differences in the hindbrain area of both *X. laevis* and *B. marinus* as part of a larger study involving the effects of the putative endocrine disruptor, atrazine, on the sexual differentiation of the brain and gonads of these two species.

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Giant Canadian snakes and forensic phylogenetics

Over the past decade, one of us (JW) has been collecting and recording stories about unusual animals in the Manitoba wilderness of Canada. While many of the creatures described by Native peoples are highly peculiar, one group of legendary beasts are large "stove pipe" sized snakes. Recently, a two meter plus shed was found in the wilderness of Manitoba. Intrigued, we isolated DNA from the shed and amplified and sequenced a portion of the cyt-b gene. This sequence was compared in a phylogenetic context with cyt-b sequence from a number of booid taxa. Based on these analyses, the shed appears to have come from a boa constrictor from northwestern South America.

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The hybrid sole, *Inopsetta ischyra* (Jordan and Gilbert), hybrid or biological species?

The hybrid sole, *Inopsetta ischyra*, has been a disputed taxonomic unit since it was first described as a biological species by Jordan and Gilbert in 1880. The majority of authors have regarded the hybrid sole not as species, but as an intergeneric hybrid between the English Sole, *Parophrys vetulus*, and the Starry Flounder, *Platichthys stellatus*, both of which are common to coastal waters of the eastern North Pacific and considered commercially important. Assuming hybridization is occurring, effective management of these two parental species requires a thorough understanding of the nature and directionality of hybridization, as well as the effects hybridization has on indigenous populations. Using allozymic data, we investigated the hybrid sole to determine whether it is a biological species or the product of natural hybridization. To further test a hypothesis of hybridization, a region of cytochrome b was sequenced and analyzed using restriction fragment length polymorphisms (RFLP) to investigate the directionality of gene flow and potential backcrossing of F1 hybrids with parental species.

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Macronutrient absorption efficiencies of the side-blotched lizard, *Uta stansburiana*, fed domestic crickets, *Acheta domestica*

Macronutrient absorption efficiencies of the side-blotched lizard, *Uta stansburiana* fed domestic crickets, *Acheta domestica* were determined for dietary proteins,

carbohydrates, and lipids. The concentration of each proximate constituent was measured in a homogenized feces sample from ten captive *Uta stansburiana* and compared to that in domestic crickets, the only source of food. A bicinchoninic acid (BCA) assay was used to quantify protein concentration; the concentration of soluble carbohydrates and lipids were determined following the methods of Dubois (1956) and Freeman (1957), respectively. *Uta stansburiana* absorption efficiencies were 77% for proteins, 83% for soluble carbohydrates, and 78% for lipids.

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Using demographic models to determine sustainable fishing for elasmobranchs: Pitfalls, advances and applications

Leslie matrices and life history tables are demographic simulation models that are commonly used to evaluate the ability of specific elasmobranch life history strategies to sustain given levels of fishing pressure. In many cases, the application and interpretation of model results are presented without a clear logical basis. Estimates of maximum population growth rates (r -intrinsic) and therefore maximum sustainable fishing mortality are being used to evaluate extinction risks to depressed stocks and guide management decisions. However, neither a Leslie matrix nor a life table can be used to estimate r -intrinsic without additional information. In this paper, we first review the logic of demographic analysis, show basic relationships and discuss what can and cannot be inferred. We then discuss how models can be extended and what additional inferences can be made when additional information is available. We derive and apply methods for estimating r -intrinsic for the barndoor skate (*Dipturus laevis*) and obtain an estimate of 0.33 to 0.50 yr⁻¹. For the lemon shark (*Negaprion brevirostris*), r -intrinsic is estimated to be between 0.04 to 0.06 yr⁻¹.

***GEERINCKX, TOM; ADRIAENS, DOMINIQUE**

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Growth and developmental features in young suckermouth catfish (*Ancistrus cf. triradiatus*, Loricariidae, Siluriformes)

The catfish superfamily Loricarioidea is characterized by an evolution from a general, omnivorous feeding type towards a highly specialized feeding type. This specialization is most pronounced in the family of Loricariidae or armoured suckermouth catfish, i.e. feeding by scraping of algae from substrates, while the animals are able to attach themselves to the substrate by means of their suckermouth. In order to try to understand the developmental arising of the peculiar loricariid breathing and feeding type, the ontogeny of the head structures of a representative of the family is being studied. After breeding *Ancistrus cf. triradiatus* in the laboratory, several ontogenetic stages were examined, revealing the nature of many structures from small embryos to adults. Cleared and stained specimens have been examined, as well as serial sections (2-

5 m thick). The results revealed many features common for Siluriformes, yet several aspects of *A. cf. triradiatus* are not seen as such in other catfishes, or to a lesser extent. During ontogeny, the skull lengthens, with a slender and elongated ethmoid region pointing ventrally, and a long and bar-shaped cartilaginous hyosymplectic-pterygoquadrate plate. Meckel's cartilages point medially instead of rostrally. These and other features are considered modifications for the typical loricariid head configuration, with a ventral sucker mouth and rotated lower jaws situated posterior to the upper jaws, as seen in adult specimens. Mouth position during the earliest stages changes gradually while the volume of the ventrally positioned yolk sac decreases. Ontogenetic evidence is found for the presence of well-formed eye muscle myodomes. The skull is intensely fused with the first vertebrae. Overall ossification sequence can be functionally related to the needs of the young fish. The data are linked to observations of young specimens.

***GELSLEICHTER, JIM; COX, HEATHER**

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Vitellogenin as a biomarker of xenoestrogen exposure in the bonnethead shark, *Sphyrna tiburo*

Vitellogenin is a large glycolipophosphoprotein that serves as the precursor to egg yolk in sexually mature, female non-mammalian vertebrates. Vitellogenin is produced in the liver in response to stimulation by the gonadal steroid, 17 β -estradiol, and is secreted into the bloodstream for delivery to developing oocytes. Although the production of this protein is generally female-specific, male non-mammalian vertebrates are also capable of synthesizing vitellogenin in response to exposure to natural estrogens and environmentally relevant, estrogen-mimicking environmental contaminants or "xenoestrogens." Because of this, vitellogenin protein and gene expression assays have become valuable approaches for detecting xenoestrogen exposure and effects in a broad range of animal taxa. In this presentation, we discuss recent efforts to develop a species-specific gene expression assay for vitellogenin in the bonnethead shark, *Sphyrna tiburo*. The production of vitellogenin was induced in male *S. tiburo* by estradiol treatment. A putative cDNA fragment of *S. tiburo* vitellogenin was obtained from reverse transcribed liver RNA of estradiol-treated sharks using the polymerase chain reaction with degenerate primers based on conserved regions of vertebrate vitellogenins. Similarity analysis of sequence data confirmed the identity of this product as vitellogenin. A digoxigenin-labeled riboprobe for bonnethead shark vitellogenin was prepared via *in vitro* transcription using the cDNA template. The riboprobe was used to develop semi-quantitative assays for characterizing vitellogenin gene expression in liver of field-sampled sharks. Additionally, sequence data was used to identify a 19-amino acid fragment of the bonnethead shark vitellogenin protein that was suitable for the production of polyclonal antibodies. This peptide sequence was commercially synthesized and used to generate protein-specific probes, which will be used to develop non-lethal assays for detecting vitellogenin in shark plasma.

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Molecular systematics and phylogeography of the Texas logperch, *Percina carbonaria*

The Texas logperch, *Percina carbonaria*, is a large percid largely restricted to the Edwards Plateau of central Texas, from the San Antonio River drainage north to the Colorado River drainage. Meristic and pigmentation characters display considerable geographic variation, with strong differentiation between the San Antonio and Guadalupe river drainages and other drainages to the north. Previous phylogenetic hypotheses have only included single specimens of this taxon, so have thus not adequately assessed the relationships of and variation within this species. We examined geographic variation at the mitochondrial ND2 gene to infer relationships of this species to other members of the subgenus *Percina*, and to test whether patterns of genetic variation were concordant with the observed morphological discontinuities. We consistently failed to recover a monophyletic *P. carbonaria*. This strong congruence with the morphological variation suggests we have underestimated the overall diversity within the group, and that populations inhabiting the Brazos and Colorado drainages represent a distinct lineage worthy of taxonomic recognition. We suggest that the break provides additional evidence for long isolation of populations from the San Antonio and Guadalupe River drainages. The observed pattern of geographic partitioning within *Percina carbonaria* is especially striking when contrasted with its syntopic congener *Percina macrolepida*, which does not exhibit a similar pattern. We are in the process of preparing a formal description of this new form, and further recommend that attempts to use the group to test evolutionary tempo or rates of speciation are misguided without first critically examining patterns of geographic variation.

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Force transmission of the adductor mandibulae complex across the jaw symphysis in sharks

The symphyses are fibrous midline connections between the halves of the jaws; the morphology of these joints has a profound effect on feeding mechanics. Fusion of the symphyses facilitates durophagy by strengthening the jaws or stiffening them to allow more efficient force transfer to the balancing-side, yet this sacrifices maneuverability that may be important in prey processing. This study examined the effect of flexible symphyses on force transmission across the jaws in two shark species (*Mustelus canis*, *Squalus acanthias*) by comparing working-side, balancing-side and symphyseal bite forces during *in vivo* muscle stimulation. Although both species have unfused symphyses, the diet of *M. canis* includes hard prey, indicating a feeding mechanism that is both flexible and strong. In a jaw with a non-rigid midline connection, we would expect force to decrease with distance from the working-side. However, while bite force in *M. canis* decreased to approximately 50% at the symphysis, balancing-side forces

nearly equaled working-side values. Stimulation of the same jaw muscles in *S. acanthias* revealed a similar decrease in forces at the symphysis and considerable variation at the balancing-side of the jaw. These differences are likely rooted in interspecific variation either in jaw shape or muscle physiology. To discriminate between these hypotheses, we calculated the mechanical advantage of the preorbitalis and dorsal quadratomandibularis muscles at sequential locations along the jaw. The mechanical advantage of the muscles differed between species, indicating that the muscular anatomy influenced bite force more than the shape of the jaw. **AES GRUBER**

GERSON, MARINA M.

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Further evidence of a pursuit deterrent signaling function in the tail-wagging behavior of the zebra-tailed lizard (*Callisaurus draconoides*)

Several hypotheses have been proposed to explain the function of the conspicuous tail-wagging behavior of the zebra-tailed lizard (*Callisaurus draconoides*): the *flash concealment hypothesis* proposes that a predator's focus is drawn to the tail banding and when these bands are quickly hidden, the lizard effectively disappears; a *distraction-autotomy hypothesis* suggests that the predator's attention is drawn to the expendable tail, which can be lost with little harm to the lizard; the *warning signal hypothesis* proposes that lizards might warn conspecifics about an approaching predator; and the *pursuit deterrent hypothesis* suggests that tail-wagging by *C. draconoides* signals to a potential predator the lizard's preparedness to make an escape. I examined the tails of field collected *C. draconoides* as well as museum specimens. Regenerated tails were present in only 7.8-20% of the specimens. Low observation rates of caudal regeneration suggest two possible explanations, which may act concurrently: 1) lizards are not often subject to predatory attack and 2) when lizards are subject to predatory attack, they most often do not survive. If the tail-wagging serves to communicate lizard awareness to a predator, as in the *pursuit deterrent hypothesis*, then predators may not attack alert lizards, reducing rates of caudal autotomy. Thus, only non-alert and non-signaling lizards are attacked and bodily captured.

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Age and growth of the thresher shark, *Alopias vulpinus*, in the northwest Atlantic Ocean

Age and growth estimates were generated for the thresher shark, *Alopias vulpinus*, in the western North Atlantic using vertebral centra from 173 female, 135 male, and 11 individuals of unknown sex ranging in size from 56 cm to 264 cm FL. Males and females were aged to 22 (228 cm FL) and 24 (244 cm FL) years respectively. Male and female growth was similar until approximately age 8 (185 cm FL), after which male growth rate slowed. Female growth slowed at a later

age than males (approximately 10 years). von Bertalanffy growth parameters generated from the vertebral data using a set size at birth provided the best fit for the band counts: $L_{inf} = 226.7$ cm FL and $K = 0.16$ for males and $L_{inf} = 263.5$ cm FL and $K = 0.11$ for females.

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Phylogenetic analysis of the Fundulidae, the North American topminnows and killifishes, (Teleostei: Cyprinodontiformes) using morphological data

The Family Fundulidae includes the North American killifishes and topminnows with approximately forty-one extant species in North America, Bermuda, Cuba, and the northern Yucatan Peninsula. We conducted a parsimony analysis of morphological transformation series to elucidate phylogenetic relationships within the family Fundulidae. Based on this analysis, all four fundulid genera (*Adinia*, *Fundulus*, *Leptolucania*, and *Lucania*) are recognized as valid. The analysis supports the monophyly of *Fundulus* subgenera *Fontinus*, *Fundulus*, and *Xenisma*. The previously unclassified Pacific Coast fundulids, *Fundulus lima* and *F. parvipinnis*, are recognized as a clade sister to *F. zebrinus* and are thus placed in an expanded subgenus *Plancterus*. The fossil species *F. detillae* is recognized as sister to *F. zebrinus* lending support to a previous hypothesis that this fossil species is a junior synonym of *F. zebrinus*. The subgenus *Zygonectes* with its current composition is recognized as a paraphyletic assemblage. In addition, the inferred pattern of evolution of salinity tolerance in the Fundulidae and the relationships of the Fundulidae to other cyprinodontoid families will be discussed.

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Comparative evolution and variation of trophic morphology among and within two clades of North American cyprinids (Actinopterygii: Ostariophysi)

Cyprinids exhibit a great deal of diversity in trophic status and associated morphologies. The evolution of trophic shifts and trophic morphology, however, has not been intensively studied in these fishes. If morphology acts as a strong constraint on dietary transformations then one would expect trophic characters to coevolve, with all changes occurring at the same node of a phylogeny. I examined variation of trophic morphology in a phylogenetic context in two clades of North American cyprinids: *Pimephales* plus *Opsopoeodus* and *Erimystax* plus *Phenacobius*. Trophic characters were examined and coded using gross dissection, scanning electron microscopy, and histology. Characters include intestine length, peritoneum pigmentation, pharyngeal tooth number and structure, and jaw morphology. Dietary information was taken from the

literature. Trophic characters and diet were mapped onto phylogenetic trees based on mitochondrial cytochrome b sequences to address the following questions: 1) Do trophic morphologies track dietary shifts? 2) Do trophic characters evolve in concert (at the same node) or in a stepwise fashion. Preliminary results suggest that trophic shifts occurred multiple times in the included lineages. These shifts were accompanied by convergent changes in morphology. Most changes occur in concert, suggesting a tight link between morphology and diet. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

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Heads or tails? Sexual dimorphism in gila monsters and beaded lizards

We tested the hypothesis that helodermatid lizards (Gila monsters, *Heloderma suspectum* and Beaded lizards, *H. horridum*) show sexual dimorphism in morphological traits related to male-male agonistic behaviors. We measured body size (SVL length); head width and length; and tail lengths of 208 *H. suspectum* and 106 *H. horridum*. We tested for differences between males and females in SVL, head dimensions, and tail length using analyses of covariance. Male Gila Monsters had proportionately wider heads than females and male Beaded lizards had proportionately longer tails than females. Tail length did not differ between males and females in *H. suspectum*, nor did body size (SVL) differ between males and females in either species. Male-male combat in helodermatid lizards involves repeated sequences of strenuous, ritualized grappling postures. Male Gila Monsters use their heads in attempts to press the opponent to the ground, or to gain a superior position during repeated bouts that may last for hours. Pairs of agonistic male *H. horridum* form a spectacular body arch with their venters adpressed and snouts, forelimbs, and tail tips forming contact points on the ground. Tail strength, and possibly tail length, appear to be important factors in the ability to form a higher arch, and emerge on top when the arch collapses. Our analyses suggest that differences in head dimensions (in Gila Monsters) and tail length (in Beaded lizards) are the result of sexual selection acting through male-male agonistic behaviors in this unique lizard taxon.

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Modeling fine-scale distribution of Galápagos tortoises by integrating data across time and space

Current models examining the covariation of species occurrence and

environmental conditions focus with varying degrees on both the extent of potential occurrence and the probability of actual occupancy at a particular area. We aimed to improve on this methodology by considering finer scales. In order to aid efforts of restoring populations of Galapagos tortoises, we used presence-absence data as well as patterns of individual tortoise movements in an attempt to model the distribution of differently aged tortoises at fine geographical scales. From multiple field observations of free ranging tortoises, we examined tortoise movements by calculating their mean square displacements and evaluated those at different time scales by comparing them to a spatially diffusive model. The pattern of juvenile tortoise movement is significantly different from adults when movement directions are examined; furthermore, movement patterns of tortoises vary in time and between directions of movement. Subsequently, we related distributions of differently sized tortoises to several environmental variables extracted from remotely sensed imagery. As a consequence, combining data about movement and tortoise sizes provided a more complete distribution model that can then be used for different management scenarios by the Galapagos National Park Service. We believe that joining different approaches can only improve the modeling efforts and furthers builds onto the modeling tools and methods already developed.

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Gill arches of gobioid fishes and their bearing on relationships

The internal relationships and classification of the Gobioidae represent a major challenge in systematic ichthyology. The lack of resolution of relationships in part reflects the large size of the clade, but also the paucity of comprehensive character surveys. Gill-arch morphology has played an important role in unravelling relationships among fishes, but has been inadequately studied in gobioids. Our ongoing studies of gobioid gill arches reveal promising variation in a wide variety of gill arch structures. Some examples of apparent synapomorphies are: broad anterior process on hypobranchial 1 (*Bostrychus*, *Incara*, *Oxyeleotris*, *Ophiocara*); full articulation of hypobranchial 1 with basibranchial 2 (odontobutids); shortening of basibranchial 3 (gobiids); reduction/loss of pharyngobranchial 4 (cartilage) with concomitant articulation of epibranchial 4 with pharyngobranchial 3 (butids, *Leptophilypnus*, *Grahamichthys*, *Thalasseleotris*, gobiids); anteroventral processes on epibranchial 2 (gobionelline and sycidiine gobiids); anteroventral process on ceratobranchial 4 (some gobionellines and some gobiines). Gill arch characters will be discussed in light of evidence from other character systems.

GILLETTE, DAVID P.

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Effects of patch context on two species of invertivorous fishes in a riffle-pool stream

Lotic systems with riffle-pool geomorphology can be conceptualized as chains of habitat patches connected by an aquatic medium. Patches receive input from immediately upstream, as well as from the adjacent riparian zone. For organisms dependent on such input for food, context of an occupied patch may be a better determinant of patch quality than within-patch factors. I tested this hypothesis for two invertivorous stream fishes in a prairie-margin, riffle-pool stream. *Notropis boops* is a drift-feeder, trophically dependent on input of aquatic invertebrate drift and terrestrial invertebrate input from outside an occupied patch. *Etheostoma spectabile* is a benthic feeder, trophically dependent on the within-patch standing crop of invertebrates. I measured resource levels by quantifying benthic invertebrate density, invertebrate drift input, and terrestrial invertebrate input for ten pools and riffles. I determined the number of *N. boops* in each pool, and *E. spectabile* in each riffle, and the number of predators. I asked if resource levels differed among patches and if these differences were a function of upstream or riparian patch characteristics. Effects of resource levels on fishes were determined by comparing fish distribution among patches to that of resources, and examining fish diets in patches with different resource levels.

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Balancing space constraints with researcher needs: a survey of users of museum fish collections

Due to budgetary and/or space constraints, natural history museums can be forced to limit the number of fish collections they are able to accession. In an effort to develop a protocol for specimen accession that is both space-efficient and of greatest value to researchers, the Ichthyology Department of the Sam Noble Oklahoma Museum of Natural History conducted a survey of museum professionals who manage fish collections, and the ichthyologists who use such collections for their research. Almost all survey responses were solicited via the American Society of Ichthyologists and Herpetologists listserv. Museum professionals were asked what type of research their collections were most frequently used for, and invited to give their opinion on specific aspects of collection building and maintenance, including priorities in collection building. Researchers were asked about their research methods, and to characterize the spatial, temporal and taxonomic aspects of collections necessary to answer their research questions. In this poster, we present a summary of survey responses.

GILMORE, JR., R. GRANT

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Evolution of species specific call patterns in sciaenid fishes: Comparison with phyletic analyses based on comparative morphology

The phyletic relationships of western Atlantic sciaenids have been examined using morphological characters: otoliths, skeletal morphology, gas bladder structure and genetic characters. There is little disagreement between the various phyletic models at the subfamily and generic level as most studies were in agreement. Recent documentation of diagnostic species specific spawning calls in sciaenids has revealed call characteristics that follow the phyletic relationships presently considered most accurate in delineating the evolutionary history of western Atlantic sciaenids. As diagnostic sciaenid calls are produced by morphological features such as musculature associated with the gas bladder, it is not surprising that acoustic signature patterns could be associated with inter-specific morphological patterns. However, certain capabilities and behaviors associated with sound production in various sciaenid species indicate increased complexity in acoustic signal production and intra-specific behavioral interactions associated with sound production that follow proposed evolutionary lines. Evolution of social behavior in sciaenids has not been studied, however, acoustic signal complexity and documented call interactions reveal that these behaviors have increased in call variety and individual call interaction.

GLAUDAS, XAVIER

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Ontogeny of antipredator behavioral habituation in cottonmouths (*Agkistrodon piscivorus*)

Knowledge of venomous snake defensive behavior is limited, and few studies have addressed how antipredator behavior is affected by experience with a potential predator in venomous snake species. Because defensive strikes may be costly to venomous snakes, individuals with the ability to learn to discriminate among potentially harmful and non-harmful predatory stimuli should be favored by natural selection. In large venomous snakes adults are capable of successfully defending themselves against most potential predators, whereas neonates suffer higher predator-induced mortality and are faced with a large diversity of predators. Consequently, I hypothesized that the relative costs of habituation to potential predatory stimuli should vary ontogenetically. This hypothesis predicts that adults should habituate rapidly to non-harmful predatory stimuli, whereas neonates would benefit from a consistent use of active defensive displays because they are at higher risk. To test this prediction I examined daily changes in the defensive behavior of adult and neonate cottonmouths (*Agkistrodon piscivorus*) towards a standardized non-harmful predatory stimulus. As predicted, adults and neonates differed in their tendencies to habituate: adults decreased defensiveness over days while neonates did not. Adults showed habituation of striking components but not of warning displays. These results support the hypothesis that there may be

ontogenetic differences in predator perception and that the costs of over-general and over-specific predator image may be inversely related in adults and neonates, therefore preventing neonates, but not adults, from habituating.
STOYE ECOLOGY & ETHOLOGY

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Stages of adaptive radiation in Caribbean *Anolis* lizards

Adaptive radiations often occur in several stages, involving specialization along a numerous distinct ecological axis. Several recently proposed models suggest that a wide range of taxa will exhibit similar patterns of radiation in response to predictable shifts in selective pressures. Unfortunately, such models have rarely been tested quantitatively and are often largely speculative in nature: indeed, Caribbean *Anolis* lizards have been used to support two alternative models that make very different predictions about the sequence of differentiation. Both of these models agree that an early stage of the anole radiation involves the evolution of microhabitat specialist, or ecomorphs, but the two models diverge with respect to the second axis of specialization. One model suggests that divergence subsequent to microhabitat specialization occurs with respect to body size, permitting species that share a common microhabitat to occupy the same forest by feeding on prey of different sizes. The second model suggests that divergence subsequent to microhabitat specialization results primarily in geographic differentiation and specialization of species that occur in different macrohabitats (e.g., xeric forest, mesic forest). We present the first quantitative test of these hypotheses using a near complete species-level phylogeny for Caribbean anoles based on mitochondrial and nuclear DNA sequence data. We analyze this data using standard phylogenetic comparative methods and randomization tests that have been adapted for use with multistate discrete characters. Our results largely reject the hypothesis that body size divergence subsequent to microhabitat specialization plays an important role in anole diversification. However, we find strong support for the hypothesis that anole radiation occurs in two distinct stages involving the fixation of microhabitat specialization prior to subsequent divergence with respect to macrohabitat.

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Regional bycatch composition of the commercial shark bottom longline fishery of the southeast United States.

Since 1994, the Commercial Shark Fishery Observer Program (CSFOP) has been placing fishery observers aboard bottom longline boats along the Atlantic coast and Gulf of Mexico from New Jersey to Louisiana. During this time the CSFOP has collected data on all sharks and bycatch caught aboard monitored vessels. From 1994-2004 the CSFOP monitored 1,259 sets representing over 777,984 hooks

and 11,184,639 hook hours. Observations were made on 63,257 sharks and bycatch consisting of 3139 other vertebrate animals. The bycatch was dominated by batoids and bony fishes with limited sea turtle (52 individuals, 29.7% mortality), cetacean (2, 1 dead, 1 escaped), and seabird (1, released) catches. The major groups of bycatch were serranids (33.6%), batoids (19.1%) and anguilliforms (14.7%). Bycatch was not evenly dispersed over the range of the fishery. The Florida Key region in particular had a high amount of bycatch, representing over 40% of the entire fishery total. Over 75% of the batoid bycatch was caught in Atlantic waters, while over 80% of serranids, lutjanids, anguilliformes, and carangids were recorded in the Gulf of Mexico. The high percentage of bycatch in the Florida Keys reflects the fishing methodology of fishers, who frequently set on or near hard bottom, and welcomed the addition of valuable groupers and snappers in their catches.

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Genetic structure of remaining Lowland Leopard Frog populations in southeastern Arizona

Lowland Leopard Frogs (*Rana yavapaiensis*) have been extirpated from much of their historic range, including approximately half of their former range in Arizona. Historically, Lowland Leopard Frogs occupied perennial waters in the valleys and surrounding mountain canyons throughout central and parts of southeastern Arizona. Valley river systems in this area are now dry most of the year, thus relegating remaining Lowland Leopard Frog populations primarily to low-elevation mountain canyons. These populations are at risk due to isolation, habitat modification, invasive species, and a newly emerged pathogen, the chytrid fungus *Batrachochytrium dendrobatidis*. We used six microsatellites to analyze the population genetic structure of Lowland Leopard Frogs in nine drainages in the Tucson Basin of southern Arizona. We evaluated gene flow among populations, tested for patterns indicative of recent population declines, and examined evidence for whether frog movements follow drainages or straight lines across the landscape. Genetic differentiation was high and migration low among populations in different drainages, even when separated by <1.8 km. There was no evidence of population differentiation among frogs sampled at pools within a drainage. Four of seven populations tested showed some evidence of a recent population bottleneck. Isolation-by-distance analyses suggest that frog populations are primarily connected by movement through drainages and not along straight lines. Our results suggest that Lowland Leopard Frog populations in southern Arizona are surprisingly isolated from each other compared to other amphibians. Small populations probably do not undergo regular extinction and recolonization events, but contain individuals that may persist undetected at times. Our results indicate that restoring habitat along lower-elevation drainages is important for the persistence of these populations.

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A re-examination of the age and growth of sand tiger sharks, *Carcharias taurus*, in the western North Atlantic

Age and growth estimates for sand tiger sharks, *Carcharias taurus*, in the western North Atlantic were derived from 96 vertebral centra collected from sharks ranging from 94 to 277 cm total length (TL), and compared to previously published age and growth data. The oldest female and male sand tiger sharks aged in this study were 17 and 15 years of age, respectively. von Bertalanffy growth parameters derived from vertebral length-at-age data are $L_{inf} = 295.8$ cm TL, $k = 0.11$ yr⁻¹, and $t_0 = -4.2$ years for females, and $L_{inf} = 249.5$ cm TL, $k = 0.16$ yr⁻¹, and $t_0 = -3.4$ years for males. Sexual maturity is estimated to be 9-10 years for females and 6-7 years for males. Weight-to-length relationships for female and male sand tiger sharks in the western North Atlantic are; $W = 1.3 \times 10^{-4} \times L^{2.4}$ ($r^2 = 0.84$, $n=55$) and $W = 9.0 \times 10^{-5} \times L^{2.5}$ ($r^2 = 0.84$, $n=47$) respectively, and $7.9 \times 10^{-5} \times L^{2.5}$ ($r^2 = 0.84$) for the sexes combined. Our results show sand tigers possess a slower rate of growth than previously thought. This information is crucial for accurately assessing this populations ability to recover, and further justifies the need for this species to be fully protected.

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Distribution, habitat usage, and parasites of *Eucyclogobius newberryi* in northern California

Eucyclogobius newberryi, the tidewater goby, is a federally endangered species endemic to coastal lagoons and estuaries in California. Little is known about the biology of this species in northern California; thus we conducted a study to assess the distribution of *E. newberryi* in Northern California, and to assess habitat usage and parasites of *E. newberryi* population in a northern California lagoon. Presence-absence surveys during 2002-2004 have documented *E. newberryi* populations in many northern California lagoons and estuaries including localities wherein this species has not been previously recorded. Habitat usage of *E. newberryi* evaluated using a stratified random sampling technique revealed that this species is commonly associated with vegetation near freshwater outflows. Parasitological analysis has revealed the presence of microsporidium infecting the muscle tissue of *E. newberryi*. This parasite most likely represents a new species restricted to *E. newberryi*, since microsporidians are known to highly host species specific and because no other microsporidian that use Gobiidae as their host are known to infect muscle tissue. A morphological description of all discernable microsporidium life stages of this putatively is currently ongoing.

***GOMEZ-MESTRE, IVAN; TOUCHON, JUSTIN C.; WARKENTIN, KAREN M.**

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Embryo defenses against water mold infection in wood frogs, American toads, and spotted salamanders.

Early life stages are vulnerable to many environmental risks and often suffer high mortality. Amphibian embryos are often exposed to predation and/or pathogenic infection, and there is growing evidence that many species have adaptive plastic responses to these risks. Some of the most common egg-stage pathogens in temperate zones are water molds of the order *Saprolegniales*, which cause egg mortality in both anurans and urodeles. We studied the incidence of water mold infection and potential mechanisms of defense in *Rana sylvatica*, *Bufo americanus*, and *Ambystoma maculatum* from nine vernal pools in Western Massachusetts. Each spring, as ponds begin to thaw, *A. maculatum* and *R. sylvatica* lay single and communal egg masses, respectively, attached to branches in the water column. Several weeks later, *B. americanus* lays its eggs on macrophytes and leaf litter in shallower waters. Over a 2 year survey, we found no trace of water mold growing on *A. maculatum* clutches, very low incidence on *R. sylvatica* eggs, and considerably higher incidence on *B. americanus*, although infections were unequally distributed across ponds. Laboratory infection tests demonstrated that water molds cannot reach *A. maculatum* eggs through the dense and thick jelly coating, and the hyphae do not grow over bare jelly. In contrast, *R. sylvatica* and *B. americanus* are easily infected and killed. Embryos from both anuran species showed premature hatching in response to the mold growing on them, sometimes hatching even before the development of muscular response. Differences in hatching times between infected clutches and controls were larger in *B. americanus* than in *R. sylvatica*. We have observed precocious hatching in response to mold infection for *B. americanus* in the field, confirming our laboratory results. We speculate that differences in breeding phenology and clutch structure determine the degree of exposure and ultimately the impact of water mold on amphibian embryonic mortality.

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The effects of survey protocol on detection probabilities and site occupancy estimates on summer-breeding anurans.

Recent global declines in amphibian populations have created an urgent need for large-scale, long-term monitoring efforts and many anuran monitoring programs have been established that utilize volunteer-based calling surveys. Calling surveys can be effective monitoring tools; however, differences among survey protocols often bias survey results. Failure to take into account detection probabilities when monitoring anurans can lead to inaccurate inferences about site occupancy, since non-detections in survey data do not necessarily mean that a species is absent unless the probability of detection is 1. We used a likelihood-

based method, in the form of the computer program PRESENCE, to estimate detection probabilities and site occupancy rates for summer-breeding anurans. Using detection data from calling-surveys, we evaluated how detectability and site occupancy for 5 anuran species were influenced by 1) time spent listening at each site, 2) number of surveys per site, and 3) sample- and site-specific covariates. We found considerable variation among species with regards to detection probability and site occupancy across time and survey period. Longer surveys resulted in more species detections and increased detection probabilities; 13% of all species detections occurred after 3 minutes. Covariates had differing effects on occupancy and detectability among individual species. Multiple surveys per site within a season that are longer than 3 minutes are necessary to eliminate biased detection probabilities and provide truer estimates of site occupancy. Our results emphasize the importance of evaluating detection probabilities for any long-term monitoring project.

GOODE, MATT

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Variation in growth of the Tiger Rattlesnake (*Crotalus tigris*)

We studied two populations of Tiger Rattlesnakes from 1997-2005 in the Sonoran Desert near Tucson, Arizona. We captured 337 individuals, which we recaptured 204 times. We also radiotracked 77 snakes, which we followed up to five years and recaptured up to 10 times each. We extract information on growth from this rich data set, and place it into the context of environmental and geographic variation. We also examine potential effects of sex, age, reproduction, diet, activity patterns and space use on growth, and we compare growth rates of snakes with and without radiotelemeter implants.

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Phylogeography of *Entosphenus tridentatus* (Petromyzontidae)

The North American distribution of *Entosphenus tridentatus* (Pacific lamprey) spans from Alaska south to Baja California, Mexico. Documentation of declining populations, combined with a recent petition to list the under the Endangered Species Act (January 2003), have increased interest in the conservation of the *E. tridentatus*. Currently there is no information available on genetic variability within and between populations of *E. tridentatus*. To assess levels of genetic variability, we used restriction fragment length polymorphism to detect nucleotide variation at 10 sites known to be variable in *E. tridentatus* mtDNA. To date 3,000+ individuals of *E. tridentatus* have been collected from 54 drainages between British Columbia and Southern California. Preliminary analyses reveal the presence of 19 haplotypes with two haplotypes occurring at high frequencies

throughout all populations.

GRACE, MICHAEL S.

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**Vision and infrared imaging: Development and functional organization of
multi-modal predatory targeting in boid snakes**

Infrared imaging systems are fascinatingly novel adaptations that allow boid and crotaline snakes to target highly motile homeothermic prey and potential predators even in the complete absence of visible light. To some degree, the infrared and visual systems are functionally redundant- neither vision nor infrared imaging is required for accurate and precise targeting, as long as the other sense is available. Even so, the two imaging systems are not independent during development: in boid snakes, unilateral loss of vision during development leads to altered targeting behavior. Unlike snakes that were developmentally normal but (experimentally) unilaterally blinded, snakes born with only one eye targeted preferentially on their sighted side unless blinded, in which case targeting was indistinguishable from normal snakes. Thus, despite the elaborate organization of the IR system and the relative evolutionary regression of eyes in boid snakes, vision may be "more important" than IR information. This conclusion is supported by the results of experiments in which the relative importance of infrared imaging and vision were directly tested in Burmese pythons (*Python molurus*). That is, snakes unilaterally blinded and unilaterally deprived of IR information contralateral to the blind side preferentially targeted on the sighted side. These snakes were capable of targeting in the infrared imaging field, but the average targeting angle was significantly different from zero and on the sighted side. These studies are providing a stronger basis for understanding the functional biology of boas and pythons and their novel infrared imaging systems, and are also helping to elucidate the principles of functional organization during development of multi-modal sensory systems.

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**The role of thermal contrast in infrared-based targeting by copperheads
(*Agkistrodon contortrix*)**

Crotaline snakes image their environments using both visible light via eyes and infrared (IR) radiation via pit organs. By analogy with the visual system, we hypothesize that the infrared imaging system may operate on the basis of thermal contrast (differential emission from objects of dissimilar temperatures), but this hypothesis has never been tested directly. Therefore, we utilized a carefully controlled experimental paradigm to investigate how thermal contrast influences IR imaging and response behavior in the copperhead (*Agkistrodon contortrix*). Temporarily blinded copperheads in a temperature-controlled arena

were presented with targets creating positive, negative, or zero thermal contrast differentials with respect to background temperature. Behavioral responses (tongue flicks, head turns and strikes) to positive and negative differentials were greater than responses to zero differentials, and snakes preferentially targeted warm aspects of thermal differentials. That is, behaviors were expressed in phase with motion of warm targets presented against a relatively cool background, but in exact antiphase with motion of cool targets against a relatively warm background. Copperheads often exhibited defensive behavior such as rapid tail vibration in response to both positive and negative differentials, and sometimes struck at moving targets. When strikes occurred, they were always directed against the arm aspect of the thermal differential (strikes never occurred in zero thermal contrast situations). These results show that thermal contrast is the basis of IR imaging in pit vipers, and suggest that infrared-imaging snakes may be "hard-wired" to respond preferentially to relatively warm objects (under the conditions of these experiments). In addition, to our knowledge this is the first direct experimental evidence that pit vipers utilize the IR system for defensive behavior. In a broader context, these results suggest that the fundamental properties of IR imaging and vision are similar. JUV was supported by a Sigma Xi Grant-in-Aid of Research.

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Habitat selection and movement patterns of marbled salamanders (*Ambystoma opacum*) and southern leopard frogs (*Rana sphenoccephala*) in altered forest habitats

Humans cause widespread changes in the landscape through development, urbanization, and conversion of land for agricultural and forestry use. These land-use changes often result in habitat loss and fragmentation, which threaten biological diversity and long-term population viability of many organisms. Migration between aquatic and terrestrial habitats and movements within terrestrial habitats are essential components to the survival and population persistence of most amphibian species and need to be investigated in regard to land management programs. As part of a larger experiment, the upland habitats surrounding two ephemeral wetlands in the Upper Coastal Plain of South Carolina were subjected to four forest management regimes (clearcut, clearcut with debris removed, thinning, control). We examined the behavioral responses of southern leopard frogs (*Rana sphenoccephala*) and marbled salamanders (*Ambystoma opacum*) to these altered habitats by releasing individuals along the edges between forest treatments and tracking them using fluorescent powder. We analyzed the data for each individual's treatment choice and microhabitat selection, and used Geographic Information Systems (GIS) to evaluate movement patterns. Leopard frogs initially (at 5m) selected recently cleared habitat, but by 60m this association was absent. Our results demonstrate the potential effects of selected forest management practices on amphibian movements.

***GRAHAM, RACHEL T.; ROBERTS, CALLUM M.**

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Movement of large fish and the design of marine reserve networks:
Results from a five year study of whale sharks in the western Caribbean

A five-year study reveals large-scale patterns of movement and fine-scale site fidelity in whale sharks (*Rhincodon typus* Smith, 1828) in relation to a temporally heterogeneous food source and network of marine protected areas. Marker, coded acoustic and satellite tags applied to whale sharks coupled with an array of passive acoustic receivers provided information on site presence versus absence, large-scale movements and timing of movement. Results indicate that whale sharks range throughout the entire Western Caribbean and its subset the Mesoamerican Barrier Reef and many of its marine reserves. Acoustically and satellite-tagged whale sharks displayed different patterns of movement. On the Belize Barrier Reef, site fidelity is highest at Gladden Spit where sharks time their arrival and departure in accordance with the availability of patchy and ephemeral food, the spawn of large aggregations of reproducing cubera and dog snappers (*Lutjanus cyanopterus* and *L. jocu*). Whale sharks demonstrated strong diel, intra-annual, and inter-annual site-fidelity to the Gladden Spit Marine Reserve. Site fidelity results indicate that the marine reserve's design encompasses the key shark aggregation area, providing site protection during their vulnerable surface feeding periods. Yet, satellite, acoustic and observational data suggest that the sharks did not reside year-round in the Gladden Spit Marine Reserve, indicating that the reserve may primarily protect a subset of the visiting whale shark population during vulnerable yet limited periods of their life. This study's results have implications for the conservation of large migratory fish and the design of marine protected area networks.

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The impacts of fishing inside a marine reserve: The Mutton Snapper spawning aggregation fishery at Gladden Spit, Belize

The Mutton Snapper (*Lutjanus analis* (Cuvier)) spawning aggregation fishery in the Gladden Spit Marine Reserve remains the last commercially fished in Belize and one of the few to occur inside a marine protected area. Analysis of inter-seasonal catch, effort and yield of this small-scale fishery revealed a significant 58.5% decline in catch per unit effort (CPUE) and a decrease of 22% in mean landings per fisher between 2000 and 2002. Over the same period the mean number of fishers increased by 27% and boats by 25% and these were accompanied by a significant 34% increase in the mean time spent fishing. Mean mutton snapper fork-length in catches decreased by 4.2%. The worth of the fishery was estimated at US\$35,497 in 2002. Combined with historical fisher accounts of previous abundance, results indicate that the Gladden Spit mutton snapper population is primarily impacted by the fishery and is unsustainable even at the current level of small-scale artisanal fishing. These findings mirror

trends noted in numerous historical extirpations of other spawning aggregations in Belize and worldwide. Management of this fishery is further complicated by its traditional nature and lack of suitable economic alternatives for older fishers.

***GRAHAM, SEAN; GROBER, MATTHEW S.; SCHUETT, GORDON**

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Seasonal timing of the mating period in cottonmouths (*Agkistrodon piscivorus*): Evidence from sex steroids, urogenital tract histology, and male sexual behavior

To address seasonal timing of mating in the cottonmouth (*Agkistrodon piscivorus*), a field study of behavior, sex steroids, and urogenital tract histology was undertaken. Male cottonmouths were bled immediately upon capture and plasma samples tested for concentrations of T and E2 using RIAs. Histological examination of the right urogenital tract was completed using standard microtome techniques. A strict observation regimen was conducted to compare the above data to actual mating (male-male agonistic encounters/male-female courtship) behavior. A seasonal profile of mating behavior, steroids, and urogenital tract histology was used to provide evidence for either a unimodal or bimodal breeding season in *A. piscivorus*. **SSAR SEIBERT MORPHOLOGY & PHYSIOLOGY**

***GRANT, TARAN; MCDIARMID, ROY W.; MEANS, D. BRUCE**

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Colostethus roraima: Another phytotelm-breeding dendrobatid

Phytotelm breeding is known in a number of brightly colored, toxic dendrobatids but has only been reported for two non-aposematic species. Test (1956, Occ. Pap. Mus. Zool., Univ. Michigan 577: 1-9) and La Marca and Mijares-Urrutia (1997, Comun. Mus. Ciênc. Tecnol.-PUCRS, Sér. Zool. 10: 3-11) referred tadpoles found in bromeliads to *Colostethus bromelicola* because adults of that species were collected in the same bromeliads, and Bourne et al. (2002, J. Herpetol. 35: 272-281) observed directly *Colostethus beebei* breeding in phytotelmata. Here, we add *Colostethus roraima*, which was previously known only from the juvenile female holotype. Adults and larvae were collected in tank bromeliads at the base of the cliffs near the north prow of Roraima, Guyana. Larval identity was determined by comparison of DNA sequences. We describe larval and adult morphology and discuss briefly the relationship of this species to other phytotelm-breeding *Colostethus*.

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Antipredator response and palatability of Yosemite toad larvae to nonnative brook trout in California

Introduction of non-native trout into fishless lakes in the Sierra Nevada Mountains of California has been shown to adversely affect some native frog populations through predation. The Yosemite toad (*Bufo canorus*) is also declining throughout its range in the Sierra; however, many tadpoles of the genus *Bufo* possess chemical toxins and are thought to be unpalatable to fish. To determine the effect of trout on Yosemite toads, we performed two experiments. In the first experiment, the antipredator behavior of Yosemite toad tadpoles in response to brook trout (*Salvelinus fontinalis*) chemical cues was measured by change in tadpole activity levels using a gravitational flow-through system. We found that Yosemite toad tadpole activity and refuge use did not differ in the presence or absence of the trout. In the second experiment, palatability of Yosemite toad larvae to brook trout was assessed by conducting choice experiments in which Yosemite toad and Pacific treefrog (*Hyla regilla*, a known palatable species) tadpoles were offered to starved trout. No Yosemite toad tadpoles were consumed by trout during the experimental trials, while trout consumed treefrog tadpoles readily.

GRAY, KURTIS N.

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Population genetic structure of the marlinsucker, *Remora osteochir* (Perciformes: Echeneidae) inferred from mitochondrial control (D-loop) DNA sequence analyses

The family Echeneidae (remoras) consists of eight recognized marine fish species found in tropical and subtropical waters worldwide. Facilitated by a modified dorsal fin in the form of a transversely laminated cephalic suction disc, these fishes readily attach to an array of hosts, including bony fishes, sharks, rays, marine mammals and reptiles. The marlinsucker, *Remora osteochir*, almost exclusively associates with istiophorid billfishes and exhibits depressed free-swimming behavior. As such, the phylogeographic distribution patterns of this species are likely to be affected by the distribution and movement of their istiophorid hosts. To date, a comparison of host and symbiont phylogeography of these pelagic fishes has not been conducted. The aim of this study was to evaluate patterns of genetic partitioning among subpopulations of *R. osteochir* collected from Atlantic and Pacific oceans. To test the null hypothesis that a single, panmictic population of *R. osteochir* is distributed worldwide, complete mitochondrial control (D-loop) DNA sequences from 70 individuals collected from multiple locations within Atlantic and Pacific oceans were compared. Intraspecific variation within and among geographically distant sampling locations nested within ocean basins was used to infer population structure

within this species. Genetic variation between individuals collected from different species of billfish was assayed to test the null hypothesis that intraspecific genetic structure does not exist as a result of host specificity.
STORER ICHTHYOLOGY

***GRAYSON, KRISTINE L.; DATTELBAUM, JONATHAN D.;
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The effect of habitat on the thermal regime and activity of the angulate tortoise, *Chersina angulata*

We examined activity patterns and thermal behavior of the angulate tortoise, *Chersina angulata*, on Dassen Island, South Africa in autumn and early winter. We studied male and female adult tortoises in two habitats with different levels of vegetation cover. Plots dominated by *Tetragonia fruticosa* provided 80-90% plant cover and had an average tortoise density of 34.2 ± 0.8 SE tortoises per hectare. Plots dominated by *Trachyandra divaricata* provided 30-45% plant cover and had a higher average tortoise density of 121.3 ± 7.9 SE tortoises per hectare. Five male and five female tortoises in each habitat were outfitted with radio transmitters and Thermochron iButton temperature dataloggers. Tortoise activity was monitored daily using thread trailing. We predict that habitat density will affect the thermal regime of tortoises and result in different patterns of activity and refuging behavior. The results of this study further our understanding of ectothermic ecology, particularly in the context of changing landscapes.

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Winter ecology of a northern population of the Wood Turtle (*Glyptemys insculpta*)

Basic information on population demography and activity are essential for designing conservation plans for declining species. In addition, seasonal variation in activity patterns of reptiles requires physiological and behavioural adjustments that influence both their ecology and life history. A northern population of wood turtles (*Glyptemys insculpta*) in the Sudbury District, Ontario was surveyed in fall 2004 and a subset of adults (N = 5) radio-tracked during the winter of 2004-2005. I examined population demography and size, winter movements and home range size, and characteristics of hibernation sites. A total of nine turtles (4 females, 4 males, 1 juvenile) were captured. Mean maximum carapace length for the 8 adults was 20.6 cm for males and 21.2 cm for females. Combining data from our survey and that of previous preliminary surveys, population size along an approximately 17 km stretch of river was estimated to be 120 turtles (95% CI = 51 to 189). Turtles did not use distinct structures (e.g., root hollows, logjams, and holes in the riverbank) for hibernation, but instead

rested relatively exposed on the riverbed at a depth of approximately 1m and at a mean distance of 0.99 m from the riverbank. Surprisingly, turtles made small movements during winter, typically in a direction parallel to the riverbank. Average winter home range size was 4.40 m². The findings of my study contribute to a better understanding of the over-wintering ecology of *G. insculpta* at its northern limit. These data are especially important because *G. insculpta* is declining in numbers, and is particularly vulnerable to increases in adult mortality (that may occur during hibernation) because of slow growth, late maturity, and high mortality of eggs and juveniles.

***GREEN, J. JEFFREY; COBB, VINCENT A.**

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Influence of thermal habitat variation on body temperature selection of an active, diurnal snake, *Coluber constrictor*

Body temperatures (T_b) of *C. constrictor* can be influenced by differences in operative environmental temperatures (T_e) of various habitats (cedar field, field, forest, glade). Thermal physical models of snakes were used to measure T_e s in four different habitats where *C. constrictor* occurred. Body temperatures of 11 individuals recorded at 30 min intervals ($n = 22,048 T_b$) were used to define a field-selected thermal preference (T_p) range (29.5–35.5°C). *Coluber constrictor* primarily exhibited plateau T_b patterns allowing for less variation in T_b s during the active period (1000–1700 hrs) despite considerable variation in T_e s (95% C.I. = 23.6–42.1°C) during that same time. Operative environmental temperatures differed between habitats and across seasons, but some habitats (field, cedar field) were more thermally suitable for *C. constrictor* to remain within its T_p range. The availability of T_e s within the T_p range of *C. constrictor* increased between April and August, with the largest change in availability occurring in the forest. Maximal availability of T_e s within the T_p range occurred during the summer (34.5% of the available thermal habitat) with the amount of time within the T_p range varying from 5.6 hrs in a forest to 8.8 hrs in a cedar field. During the month of August both the field (44.5%) and glade (41.5%) had similar thermal availability and were higher than the forest (30.6%) or cedar field (35.1%). Despite the high thermal availability in open glades, *C. constrictor* was rarely observed there. Instead, *C. constrictor* remained in more covered habitats such as the forest, field, and cedar field. Ecotones between these habitats were greatly used by *C. constrictor* and provided areas where snakes could shuttle between habitats. Even when warm sites were limited in a habitat, *C. constrictor* effectively used what was available to maintain high stable T_b s.

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Monitoring recruitment of the New York State endangered Eastern Tiger Salamander using annual egg-mass surveys

Egg-mass surveys are an essential part of amphibian monitoring and conservation. Understanding the characteristics of ponds and vernal pools utilized by amphibians, as well as keeping record of climatic conditions, can aid in predicting the type of recruitment a pond can expect for a given year. The New York State endangered Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*) is of special concern due to rapid development of its last remaining habitats on Long Island. Six years of egg-mass surveys have been conducted at the Brookhaven National Laboratory on Long Island, New York. The data were collected from 2000 to 2005 at multiple pond and vernal pool locations throughout the Laboratory property. Both known and unconfirmed tiger salamander ponds were surveyed during this study in order to compare pond characteristics that can predict potential occurrence of tiger salamanders in unstudied habitats. Numbers of egg masses per pond were recorded on an annual basis, as well as several habitat variables, including vegetation, water depth (both average and maximum) air temperature, water temperature, turbidity, pH, average water depth, conductivity, and dissolved oxygen levels. Presence of adult salamanders during surveys was also noted. Average monthly temperatures and precipitation were documented, as well. The data suggest that presence of egg masses is related to air temperature (both at time of survey and average monthly air temperature), average precipitation, conductivity, pH, maximum water depth, vegetation, and presence of adults. Further analysis of the data will be utilized to create a monitoring protocol to ensure these ponds are continuing to be productive, as well as providing a template for identifying potential new ponds both on and off site.

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Threat assessment and conservation prioritization of the herpetofauna of El Salvador

We applied the IUCN Red List method for threat assessment to the amphibians and reptiles of El Salvador, the smallest Central American country. Seventy-seven out of 130 species were found to be threatened or endangered at the national level. In general, most threatened taxa were aquatic organisms in lowland habitats or cloud-forest specialists in highland areas. The IUCN method was biased by collecting effort and was unable to classify 24 species that were categorized as data deficient. We used the number and distribution of threatened

species and a complementarity analysis to identify departments in El Salvador that require higher priority for conservation action. We applied a method for evaluating inventory completeness to our data set, and used species from reasonably well-surveyed taxonomic groups (Anura and Sauria) to execute the complementarity analysis. The anurans (frogs) and saurians (lizards) had been inventoried relatively completely in ten of 14 departments. The department with the most threatened species (36 of 77 threatened amphibians and reptiles) is Santa Ana, where many threatened species occur in pine-oak and cloud forest in Montecristo National Park.

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A survey of the marine fishes of Fiji

Between 1999 and 2003 we conducted a NSF funded survey of the marine fishes of Fiji; a total of 322 rotenone collections were made, including 25 on deep reefs (up to 108 meters) by collaborators Richard L. Pyle and John L. Earle, using mixed-gas rebreather gear. Several new species from Fiji have been described from shallower water, and more descriptions are in preparation. The deep-reef collections have yielded 22 undescribed fish species. The Fiji fish collections are now at the California Academy of Sciences where they are being sorted and identified. To date over 4,000 lots have been cataloged. A checklist of the fishes of Fiji is planned. Species new to science and new records from Fiji will be illustrated.

***GRIER, HARRY J.; WATERS, YVONNE; URIBE, MARI CARMEN; DE LA ROSA, GAMBINO; MEIJIDE, FERNANDO; NOBREGA, RAFAEL H.; GRASSIOTO, IRANI; LO NOSTRO, FABIANA; PARENTI, LYNNE R.**

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Attachment of follicles to the ovarian germinal epithelium in teleost fishes

Part of our work involves the documentation of an ovarian germinal epithelium in teleost fishes and the process by which follicles are produced (folliculogenesis). By definition, a follicle consists of a single oocyte that is surrounded by follicle (granulosa) cells and is separated from the stroma by a basement membrane. This definition, which is consistent with the textbook definition for a primordial follicle, is also consistent with a follicle being wholly derived from the germinal epithelium. That is, an ovarian follicle is an epithelial

derivative. In fishes whose ovarian morphology we are investigating, we consistently see that the follicle is attached to the germinal epithelium, from which it is derived. All epithelia are subtended by a supporting basement membrane. The follicle is surrounded by a basement membrane. We have observed that the basement membranes of both the follicle and the germinal epithelium merge and become one along a small part of the follicle surface, where ovulation occurs. Using light microscopy, we first observed a single basement membrane between follicles and the germinal epithelium in a goodeid, *Ilyodon whitei*, because basement membranes in this fish are particularly well-stained and the stromal cells are widely separated. However, subsequent observations, both with light and electron microscopy, have revealed the same morphology to be present in three perciform teleosts: in the common snook, *Centropomus undecimalis* (Centropomidae); in the red drum, *Sciaenops ocellatus* (Sciaenidae); and in juvenile *Cichlasoma dimerus* (Cichlidae). The attachment also occurs in *Pimelodus maculatus* (Pimelodidae), a basal siluriform teleost. We hypothesize that among fishes, follicles are attached to the germinal epithelium during their development, and this is where ovulation occurs.

***GROSS, KRISTINE S.; FAUTH, JOHN E.**

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Tree calls of three hylid treefrogs: Environmental triggers of calling frequency

During the breeding season, males of several treefrog species emit a diurnal call that is commonly called a rain call or tree call. The mating benefit of these daytime calls broadcast from the tops of trees is unknown; they may attract distant females or advertise territories. Currently, there is no information on tree calls in any frog species. I investigated how environmental variables affect tree call frequency (number of calls per hour) of barking treefrogs (*Hyla gratiosa*), pinewoods treefrogs (*H. femoralis*) and squirrel treefrogs (*H. squirella*) by testing the null hypothesis that tree call frequency is unaffected by temperature, relative humidity and barometric pressure. I predicted that high temperature and relative humidity and low barometric pressure would stimulate more tree calls because they indicate impending rain that precedes amphibian breeding. Results of my study indicate that environmental parameters when tree calls were given varied among species. For example, *Hyla femoralis* gave tree calls at a lower mean temperature than both *H. gratiosa* and *H. squirella*, which called at a similar mean temperature. All three species preferred a different mean relative humidity at which to give tree calls; *Hyla femoralis* at the highest, *H. gratiosa* a little lower, and *H. squirella* at the driest. *H. squirella* also called at a lower barometric pressure than both *H. femoralis* and *H. squirella*. My results can be used to develop monitoring strategies for conservation and restoration efforts for these treefrogs and other species that give tree calls. It also provides information on the life history and mating behavior of *H. femoralis*, which is used as an indicator species by the U.S. Forest Service. **SSAR SEIBERT ECOLOGY**

***GROSSMAN, GARY D.; RATAJCZAK, JR, ROBERT E.; PETTY, J. TODD; HUNTER, MARK D; PETERSON, JAMES T.; GRENOUILLET, GAEL**

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Population dynamics of mottled sculpin in a variable environment: An information-theoretic approach

We used strong inference with AIC to assess the processes capable of explaining long-term (1984-1995) variation in the per capita rate of change of mottled sculpin populations in the Coweeta Creek drainage (USA). We sampled two 4th and one 5th order sites (BCA [uppermost], BCB, and CC [lowermost]) along a downstream gradient, and the study encompassed extensive flow variation. Physical habitat availability varied significantly both within and among the sites. Sculpin densities in all sites were highly stable (CVs 0.23 - 0.41). Population stability was positively associated with habitat stability and there were few significant correlations of population parameters among sites (juveniles only). Sculpin densities were significantly higher in BCB than in CC. The data suggest that despite their proximity, the dynamics of populations within the sites are being determined by small-scale (i.e. 30-50 m) rather than by broad-scale spatial processes. Both AIC and Dennis and Taper analyses indicated that simple density-dependence had the greatest ability to explain variation in r for all life-history classes in all sites (AIC 7/9 cases, D&T 9/9 cases). Multi-process models had little explanatory power. When adults were removed from two sites, juvenile sculpin shifted into microhabitats formerly occupied by adults. No shifts occurred in control sites. Consequently, it is likely that the patterns of density-dependence observed in all three sites were a consequence of intraspecific competition for space. Our findings argue for a multi-tiered approach to the study of population variation, one that encompasses long-term monitoring, spatial variation, and experimental testing of potential mechanisms.

***GRUBBS, R. DEAN; HOLLAND, KIM N.; ITANO, DAVID G.**

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Trophic ecology of young-of-year yellowfin tuna (*Thunnus albacares*) in Hawai'i

The trophic ecology of yellowfin tuna (*Thunnus albacares*) has been described by numerous researchers in many regions of the Atlantic, Pacific, and Indian Oceans. With few exceptions, these studies concluded that these are opportunistic predators that feed on diverse forage bases, though only a few families of epipelagic teleosts and crustaceans often compose the majority of the diet. Most of these studies only included adult tunas, however. Very little data

have been published on the feeding and ecology of young-of-year tunas, in part due to a lack of information concerning the distribution of the early life stages throughout much of the species' range. The Hawaii Institute of Marine Biology, in cooperation with the State of Hawaii's Division of Aquatic Resources, monitors and maintains 55 anchored FADs around the main Hawaiian Islands. Young-of-year yellowfin tuna aggregate to these FADs in large numbers throughout the year. Between October 2002 and October 2004, we collected the stomach contents of nearly 1,000 young-of-year yellowfin tuna (19.0 - 50.0 cm fork length) from 12 different anchored FADs around the island of Oahu. Overall prey diversity was very high and primarily included micronektonic animals associated with the upper mixed layer, rather than organisms associated with the FADs. In total, 74 families of prey were identified, including 34 families of fishes, 30 families of crustaceans, and 9 families of molluscs. The larvae of seven families of stomatopod and decapod crustaceans were dominant in the diet, though the importance of small epipelagic fishes and the pelagic larvae and juveniles of reef-associated fishes increased ontogenetically.

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Analysis of fall migration of cownose rays, *Rhinoptera bonasus*, using pop-up satellite archival tags

The life history of the Cownose Ray, *Rhinoptera bonasus*, has been well studied in the Chesapeake Bay, which serves as a primary nursery for young-of-year pups during the summer months. In order to further the understanding of the population biology of the cownose ray, fall migration of cownose rays was examined and the wintering grounds identified. Seven adult female cownose rays were tagged with Pop-up Satellite Archival Tags (PSATs) in the lower Chesapeake Bay in early September 2003. The tags were programmed to release and begin data transmission after six months. Data collection by the tags was excellent; however, data transmission was very poor. Three tags were found on Florida beaches and returned for download of archival data. Comparison of tag data to oceanographic sea surface temperature (SST) data and coastal bathymetry contours showed that the rays had very similar migratory behavior in terms of temperature and depth preferences. They moved from Chesapeake Bay down the South Atlantic Bight at a migration rate of approximately 6.7 NM/d arriving in southern Florida around late December. Based on SST comparisons, none of these rays migrated south of 27 °N. Two potential gestational patterns have been suggested for cownose rays – semi-annual reproduction vs. annual reproduction with mid-gestation diapause. In contrast to the estuary-based summer grounds, cownose rays remained off-shore during the winter months near the continental shelf break where it approaches the Florida coastline. The energy required for long-distance migration plus the stark contrast of the wintering grounds to the rays' summer residence make a winter nursery unlikely. **AES GRUBER**

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Quantification of forces imposed by Pop-up Satellite Archival Tags and estimation of metabolic cost

The recent development of the Pop-up Satellite Archival Tag (PSAT) has allowed the collection of information on a tagged animal including geolocation, pressure (depth) and ambient water temperature. The success of early studies on pelagic fishes has spurred increasing interest in using these tags on a large variety of species and age groups. However, some species and age groups may not be suitable candidates for carrying a PSAT due to its relatively large size and the consequent energy cost to the study animal. Potential energetic costs of carrying a tag in the cownose ray, *Rhinoptera bonasus*, were examined. Two forces act on an animal tagged with a PSAT: lift from the PSAT's buoyancy and drag as the tag is moved through the water column. In a freshwater flume, a spring scale measured the total force exerted by a PSAT at flume velocities from 0.00 - 0.60 m/s. By measuring the angle of deflection of the PSAT at each velocity, the total force was separated into its component forces, lift and drag. The power required to carry a PSAT horizontally through the water was then calculated from the drag force and velocity. Using published metabolic rates, the power for a ray of a given size to swim at a specified velocity (i.e. swimming power) was estimated. For each velocity, the power required to carry a PSAT was compared to the swimming power expressed as a percentage, %TAX. A %TAX greater than 5% was felt to be energetically significant. Our analysis indicates that a ray larger than 14.8 kg can carry a PSAT without exceeding this criterion. The approach can be applied to other species allowing a researcher to decide the suitability of a given study animal for tagging with a PSAT. **AES CARRIER**

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Measuring catch-and-release mortality of tarpon using ultrasonic telemetry in Boca Grande Pass, Florida

Florida regulations require anglers to purchase a \$50.00 tag (i.e., permit) to harvest or possess a tarpon, *Megalops atlanticus*. The number of tarpon tags (permits) sold and used each year in Florida has been used to estimate annual tarpon fishing mortality due to harvest; however, applying the number of tarpon tags reported as used to determine annual fishing mortality in a predominantly catch-and-release fishery is unrealistic. In this study, we used ultrasonic telemetry to obtain current estimates of catch-and-release mortality rates for tarpon in Boca Grande Pass, and we evaluated the potential effects that tackle used, hook placement, and fight time might have on fishing mortality. Tarpon landed on fishing charters were tagged with ultrasonic transmitters, released, and tracked with a hand-held receiver by observers in a boat for up to 6 hours, with swimming and behavior patterns recorded every 15 minutes. Of the 41 tagged tarpon, four were visually unconfirmed mortalities inferred from their

lack of movement and behavior and three tarpon were visually confirmed to have died as a result of shark attacks. The catch-and-release mortality rate evaluated for this study ranged between 7.3% and 17.1% (7 out of 41). Statistical comparison showed no significant difference between jig- and live-bait fishing methods on catch-and-release mortality rates in Boca Grande Pass. No association between tackle used, hook placement, or fight time and tarpon catch-and-release mortality could be detected; however, the condition of the fish at time of release and angler handling may affect survival. The tarpon that died were significantly smaller in total length than the survivors. Tagging studies can be a valuable tool for estimating post-release mortality of game fish, especially for large species that might be difficult to maintain in floating pens or tanks.

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The relative roles of predation and competition in the habitat distribution of two sister taxa of hylid treefrogs

Closely related species which co-occur over large portions of their geographic ranges must have mechanisms to partition habitat. The objective of this study was to evaluate the roles of abiotic habitat characteristics, competition, and predation in influencing the habitat distribution of two sister taxa of Hylid treefrogs. These species co-occur throughout the southeastern United States, but *Hyla cinerea* typically breeds in permanent ponds, while *H. gratiosa* breeds in temporary ponds. In order to compare the relative role of predation and competition and abiotic effects, I performed experiments that compared survival and fitness of each species under the conditions of its native habitat type and the other habitat type. A mesocosm predation experiment demonstrated that survival of both tadpole species was similar for both a permanent pond predator (warmouth sunfish) and a temporary pond predator (libellulid odonate naiad). However, there was a tendency for *H. cinerea* tadpoles to hide more than *H. gratiosa* with warmouth sunfish predators. A reciprocal transplant experiment using enclosures in natural ponds compared survival, larval period, and size at metamorphosis for both species raised in both habitat types. *Hyla cinerea* tadpoles had longer larval period and larger size at metamorphosis in temporary ponds. *Hyla gratiosa* tadpoles were significantly larger at metamorphosis in temporary ponds than permanent ponds, and had longer larval periods when raised with conspecifics than with *H. cinerea*. Thus, although predation regime differs in the two habitat types, predation rate alone may not be sufficient to explain the habitat distribution of these species. Although both species are capable of surviving under the environmental conditions of either pond type, the longer larval period of *H. cinerea* in temporary ponds may result in increased exposure to predation. This research demonstrates the difficulty of teasing apart the complex mechanisms responsible for the distribution of species across habitats.

HL JAEGER

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Ecology of the snapping turtle, *Chelydra serpentina*, in northwestern Florida

Chelydra serpentina is an abundant and wide-ranging species of turtle in the eastern United States, but relatively little is known of the basic ecology of this species in the southern portion of its range. The objective of our study was to provide baseline information on the demography and ecology of *C. serpentina* in northwestern Florida. We intensively sampled five localities in Leon Co., Florida using traps and hand-collecting (n= 111), and also opportunistically collected *C. serpentina* as we encountered them through the course of other studies (n = 11). Analysis of seven morphological characters from a subset of individuals (n=35) indicated that *C. serpentina* in this study are intergrades between *C. s. serpentina* and *C. s. osceola*. *Chelydra serpentina* abundance varied over the sites surveyed but was highest in small suburban ponds with abundant aquatic vegetation with an average density of 16/ha. Estimated early growth rates were 20 mm carapace length (CL)/year. Male *C. serpentina* (CL mean = 294 ± 7 mm) were larger than females (CL mean = 266 ± 5 mm) and the adult sex ratio was 1:1. Diet consisted of mostly aquatic plant material (n = 3). Nesting females were found from early Apr through mid May and clutch size ranged from 5 to 49 eggs (n = 3). There is some variation in ecological and demographic characteristics of *Chelydra serpentina* throughout its geographic range, and further studies in the southern portion of its range are needed.

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Effects of hydrological alterations and introduced species on amphibian populations in a wellfield in southwest Florida

Amphibian populations have been declining since the 1950s, largely due to habitat destruction, water pollution, and introduced species. Amphibians use wetlands, thus, wetland impacts are often the cause of amphibian declines on a local level. We studied frog and toad populations in wetlands at the Tampa Bay Water Morris Bridge Wellfield in Hillsborough County, Florida. Wetlands in zones representing different groundwater drawdown levels were studied to determine if hydrologic changes, due to unsustainable groundwater pumping in the past, have affected anuran populations. Tadpoles were sampled at 16 wetlands in three different drawdown zones at the wellfield from June to August 2004. Nighttime anuran call surveys were also conducted throughout the wellfield at monthly intervals. While there was no significant difference in the number of tadpole species by zone, Zone 4, which is unaffected by groundwater pumping, had significantly higher tadpole densities compared to the other two zones. Cuban treefrogs (*Osteopilus septentrionalis*), an introduced species known to compete with and consume native frog species, appear to be affecting native

species at Morris Bridge Wellfield. Long-term studies will continue to determine if anurans will recover over time as hydroperiods are restored, to determine whether or not anurans are good sentinels for wetland restoration, and to assess the potentially confounding influence of Cuban treefrogs in the recovery of native species at this site.

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Insights from analysis of 30 years of Virginia shark long-line survey data

The Virginia Institute of Marine Science has been conducting shark long-line surveys with standard gear in Virginia waters since 1973. Only one analysis of these catch data have been presented to date. In this paper we present the results of analysis of trends in abundance over the last 30 years of Virginia sharks species. We also examine patterns of abundance with physical parameters, and examine size distribution data for changes in the last 30 years. Our analysis shows a clear decline in abundance of virtually all shark species caught often enough for statistical analysis. Sandbar (*Carcharhinus plumbeus*), dusky (*C. obscurus*), sand tiger (*Carcharias taurus*), and tiger (*Galeocerdo cuvieri*) all show significant declines. Only small shark species such as the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) and the smooth dogfish (*Mustelus canis*) show equivocal trends. Breakdown of sandbar shark abundances into size classes show trends in abundance to be driven by juvenile sharks, with adults virtually not appearing in recent years of our survey. Physical parameters examined include bottom and surface temperatures, times of day lines were set and retrieved, month of survey, location, and depth. Bottom temperature is the most consistently significant parameter in our models, with month of survey being significant in certain cases. Time of set and retrieval are virtually never significant. Size-distribution curves can only be studied for the most abundant species collected in this survey, and, to date, only the most abundant, the sandbar shark, has been studied in this manner. These results show loss of larger individuals over the course of the survey, with some less obvious trends still to be teased out. Future work will include analysis of additional physical data, analysis of larger-scale meteorological data, including North Atlantic oscillation data, and analysis of trends in catches of other elasmobranchs (batoids) caught as bycatch.

***HABIT, EVELYN M.; BELK, MARK; TUCKFIELD, CARY; PARRA, OSCAR**

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Response of the fish community to human-induced changes in the middle lower zone of the Biobio River (Chile)

The Biobio river basin of south central Chile exhibits the greatest species richness of all rivers in Chile, and it is also one of the most important rivers in Chile for human use. Use of this fluvial system has increased dramatically during the last

decade. To avoid loss of native fish populations and species in this river, it is critical understand the effects of human induced changes. We compared current patterns of distribution and abundance of fishes to the expected pattern of longitudinal zonation, and we compared current patterns of distribution and abundance to data from studies conducted before the rapid development of the last decade. Species composition, distribution, biomass, abundance, and fish diversity was studied at eight sampling stations in the middle and lower zones in both high and low flow seasons. Contrary to the pattern observed in less impacted river systems, species richness, diversity, and abundance (cpue) all tended to decrease downstream from the uppermost sampling locations. Comparison with previous records indicates loss or reduction in range of native species and sensitive introduced species (e.g., salmonids), and a concurrent expansion in range and abundance of tolerant introduced species (e.g., *Gambusia holbrooki*, and *Cyprinus carpio*) over the last 10 to 15 years. These comparisons suggest a large scale and cumulative long term effect of recent human impacts on the river. Control and reduction of polluting effluents and conservation of native fishes are urgently needed to avoid extinction and subsequent loss of diversity in the fish fauna of the Biobio River.

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Influence of physical factors and introduced rainbow trout on zonation patterns of native fishes in Chilean coastal rivers

Typically, physical factors such as water velocity, gradient, and habitat structure, are suggested to be important determinants of longitudinal zonation patterns of fish assemblages in rivers, but seasonal high flows and introduced species also may affect native fish community structure. To determine factors which affect the composition, abundance, and distribution of native and introduced fish species along a river during high flows, we sampled habitat characteristics and fish assemblages of rithral, transitional, and potamal zones in three sub-basins of the Andalien basin of central Chile in two consecutive months representative of the high flow season. Cluster analysis of fish species based on abundances revealed three distinct groups that correspond to the breadth of distribution rather than occurrence in specific locations. Physical variables were essentially univariate among locations, and only weakly predictive of relative abundance of species. Introduced *O. mykiss* abundance was not a significant predictor of native fish abundance above and beyond the physical variables. In this drainage longitudinal zonation results from nested subsets of fish species that make up assemblages of different river zones with most species occupying potamal areas. These data suggest that introduced *O. mykiss* occupy a vacant niche in rithral zones of coastal Chilean rivers and have relatively little effect on the distribution of native fish during high flow periods.

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Microsatellite variation and population structure of alligator snapping turtles

The alligator snapping turtle (*Macrochelys temminckii*) is found in drainages of the Gulf of Mexico in the southeastern United States. In recent decades, populations have declined throughout this turtle's range, and as a result, the alligator snapping turtle is now listed as a species of conservation concern by every state within its range. Roman et al. (1999), suggested that, based on their mitochondrial data, alligator snapping turtles occurring in the Mississippi River and drainages west of there share the same haplotype. Combinations of multiple genetic markers can provide better resolution of genetic structuring. To achieve this, we quantified levels of genetic variation across 2 trinucleotide and 8 tetranucleotide microsatellite loci for populations of alligator snapping turtles occurring within the lower Mississippi River drainage and the Trinity and Neches drainages in east Texas. For each locus, we calculated allelic and genotypic frequencies, observed heterozygosity (HI), average expected heterozygosity (HS), and total expected heterozygosity (HT), and determined if each locus met Hardy-Weinberg expectations. Using AMOVA, we determined proportions of molecular variance resulting from variation within individuals (FIT), within populations (FIS), and between populations (FST).

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Aspects of the life history of the Brown Smoothhound, *Mustelus henlei*, from southern California

Various aspects of the life history of the Brown Smoothhound, *Mustelus henlei*, are being examined in a Southern California population from Catalina Harbor, Catalina. Age and growth of the adolescent and adult specimens will be described using the Von Bertalanffy growth function, as well as the species fecundity and length at birth. I am also examining the age and growth of *M. henlei* fetuses, as well as the sex ratio at birth. The diet of the brown smoothhounds from Southern California is also being examined. Preliminary data indicates that the diet of the brown smoothhounds from Catalina Island is dominated by Teleosts, including juvenile *Atractoscion nobilis*, crustaceans, and cephalopods.

***HALE, LORI F.; DUDGEON, JOHN; MASON, ANDREW Z.; LOWE, CHRISTOPHER G.**

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Elemental signatures in vertebral cartilage of the round stingray, *Urobatis halleri*, from Seal Beach, California

Elemental analyses (x-ray spectrometry, electron microprobe analysis) have been used to verify ages in elasmobranchs by examining seasonal peaks of elements in cartilage growth. These studies found that there were annual cycles of calcium and phosphorus that corresponded with age estimations. In the current study, a new technique for elemental spatial analysis involving time-of-flight inductively-coupled-plasma-mass spectrometry (TOF ICP-MS) has been used to assess the potential of verifying age estimates and seasonal banding patterns in the vertebral centra of the round stingray, *Urobatis halleri*. This technique uses a high-energy UV laser to ablate a sample, which is then swept into the ICP-MS by a pressurized argon stream. The spatial distribution of elemental signatures was compared to the annual and seasonal periodicity of growth bands used for age estimation. Vertebral centra were sectioned sagittally producing 0.5 mm thick bow-tie sections. The sample sections were pre-ablated with the laser to remove external contamination and the ICP-MS chamber was purged to remove leftover gaseous elements. Each sample was laser ablated across the whole vertebral corpus calcareum at a speed of 10 micrometers sec⁻¹ with a laser spot size of 30 micrometers. Calcium, phosphorus, magnesium, and strontium were the main elements screened in the vertebral sections. Preliminary results show that spatial peaks in calcium, phosphorus, strontium, and magnesium concentrations may correlate with growth bands in the vertebral centra. In addition to verifying age estimates, this analysis could be applied to determine possible location of nursery grounds that may possess distinct elemental characteristics and dispersal patterns of the round stingray. **AES CARRIER**

***HALE, LORI F.; LOWE, CHRISTOPHER G.**

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Age and growth of the round stingray, *Urobatis halleri*, at Seal Beach, California

The round stingray, *Urobatis halleri*, is the most common nearshore elasmobranchs in southern California and is particularly abundant at Seal Beach, California. The popularity of Seal Beach for both beachgoers and stingrays, results in 200-500 round stingray-related injuries each year. However, it is unclear why round stingrays aggregate at Seal Beach. Because of the desire to reduce the number of round stingray-related injuries, knowledge of the age and growth of this species is important for management. Round stingrays were collected monthly in beach seines at Seal Beach, California in 2003 and 2004 (n=171). Vertebral centra were sectioned and age was estimated by two readers. Growth models were fit to the estimated age-at-disc width data and age estimations were applied to frequencies of disc widths of round stingrays. The parameters estimated by the von Bertalanffy growth model were a maximum

disc width of 348 mm for males and 251 mm for females, $k = 0.06 \text{ year}^{-1}$ for males and 0.11 year^{-1} for females, and $t_0 = -4.61$ for males and -5.38 for females. The maximum disc width estimated was comparable to other batoids like *Urolophus lobatus* and *Trygonoptera personata*. The age structure of the population of round stingrays at Seal Beach consisted of mostly older, mature males and females. Age at maturity (150 mm disc width) corresponded to an average age of 3.8 years for females and 3.75 years for males. The maximum estimated age was 14 years old at a disc width of 239 mm for males and 213 mm for females. Males were more numerous than females throughout the year with the highest frequency of occurrence in August; however from May through September females outnumbered males. Based on the age structure of this population, round stingrays are likely aggregating at Seal Beach for reproductive purposes and this species may be sensitive to control measures. **AES GRUBER**

***HALSTEAD, BRIAN J.; MUSHINSKY, HENRY R.; STILSON, TERRI A.; MCCOY, EARL D.**

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Analysis of juvenile Gopher Tortoise (*Gopherus polyphemus*) movement paths using random walk models

Several studies have focused on the home ranges, movements, and burrow use of the gopher tortoise (*Gopherus polyphemus*). None of these studies, however, has examined these movements mechanistically using random walk models. Such models allow researchers to observe characteristics of the movement paths of individuals and use them to predict population-level phenomena such as the rate of population spread and habitat preference. In this study, we observed 25 movement paths of 11 individual juvenile (72-216mm carapace length) gopher tortoises in annually burned sandhill habitat at the University of South Florida's Ecological Research Area. Individual movement paths were described by move lengths, move durations, and turning angles, and analyzed as random walks. We calculated the net squared displacement of the movement paths to examine the rate of population spread of the gopher tortoise in frequently burned sandhill habitat. We also categorized movement paths according to the amount of cover encountered during the path and the amount of desirable forage plants encountered during the path, and compared movement paths in each category using the residence index. The residence index uses random walk parameters to characterize the effects of the environment on individual movement, and can be used to predict the spatial distribution of organisms. We discuss implications of our analyses for habitat management policies.

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Condition indices in *Aspidoscelis sexlineata*: A comparison of methods

Simple ratios have traditionally been used as indicators of the body condition of individuals. It has recently been shown that the use of residuals and ANCOVA

are more appropriate techniques for testing differences in body condition. We compared condition indices of a population of *Aspidoscelis (Cnemidophorus) sexlineata* described by Mushinsky in 1985 against these more recent techniques. We also used both methods to compare the current population at the same site to the individuals collected in the early 1980's.

***HAMMERSCHLAG, NEIL; MARTIN, R. AIDAN; FALLOWS, CHRIS**
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White Shark (*Carcharodon carcharias*) predation on Cape fur seals (*Arctocephalus pusillus pusillus*) at Seal Island, South Africa: Present knowledge and future directions

Predator-prey interactions between white sharks (*Carcharodon carcharias*) and Cape fur seals (*Arctocephalus pusillus pusillus*) were studied at Seal Island in False Bay, South Africa, from 1997 to 2003. 2088 predatory attacks on seals were recorded during the study period and frequency and success rate were analyzed according to 13 biotic and abiotic factors. Attacks were primarily on lone incoming young of the year seals, were spatiotemporally clustered at the primary pinniped entry/exit point at the south terminus of the Island, and occurred almost exclusively during winter (May-September), mostly within two hours of sunrise. Predatory success rate averaged 47%, but increased to 55% under scotopic conditions and decreased to 40% under photopic conditions. Shark attack frequency is high, averaging 5.6 per day, with as many as 26 recorded in a single day. Experiments using infrared video imaging demonstrated that both seals and white sharks can be detected in darkness by their thermal signatures and helped document that seal movement about the Island is greater at night than during the day. Sharks may control seal populations through top-down trophic effects by directly causing significant seal mortality as well as by indirectly altering seal foraging behavior due to predation risk. Current work is aimed at determining the ecological role of the white shark in False Bay and evaluating its impact on ecosystem structure and function. **AES GRUBER**

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Ecology of *Siren intermedia* in an isolated pond

The Western Lesser Siren (*Siren intermedia*) is a paedomorphic salamander that can have a major influence in aquatic communities. Few field studies have dealt with populations of this species, and some aspects of its biology are not well known. The purpose of this study was to investigate various aspects of the ecology of *S. intermedia* in an isolated pond. This study was conducted in a farm pond at Camp Tyler, Smith County, Texas. Four traps were placed in the pond during the winter and spring months, November - April, from 2002 to 2005. Captured individuals were measured for snout-vent length (SVL) and tail length,

weighed, sexed, and marked with a passive integrated transponder (PIT tag). A HOBO temperature data logger was placed in one trap to record average daily temperature. Ten individuals were sacrificed to report diet and parasites. The highest movement occurred in February and March, which coincides with the peak number of gravid females trapped and parturition. The male to female capture rate was approximately 2:1. Both males and females were found with fresh bite marks, most commonly in February. The average of SVL and mass of males were higher than those of the females. Several individuals were found with the tapeworm, *Ophiotaenia sireni*, in the gut. The percentage of parasitism in the population will be discussed as well as the dietary assessment.

***HANKEN, JAMES; MABEE, PAULA M.; KEARNEY, MAUREEN**

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Workshop/forum: Assembling the Tree of Life (AToL) for fishes, amphibians, and reptiles

The U.S. National Science Foundation currently supports three research initiatives through its Assembling the Tree of Life (AToL) program that explicitly analyze the phylogenetic relationships of fishes (*Systematics of Cypriniformes*; CToL), amphibians (*AmphibiaTree*), and squamate reptiles (*Deep Scaly*). This half-day workshop will communicate basic information and opportunities regarding these programs and provide a forum to discuss both conceptual and practical issues that pertain to the analysis of phylogeny and evolution. The CToL component – "Laying a foundation for collaborative systematics: where we are and what we can envision" – will provide an overview of the Cypriniformes grant (Rick Mayden), an introduction to analysis of the morphology of fossil fishes (Gloria Arratia), and an outline of plans to integrate AToL-related studies with available phenotype and genomics databases for the zebrafish. The *Deep Scaly* component will include an overview of the project's structure and goals, including novel approaches to morphological data analysis and consideration of fossils (Maureen Kearney). The *AmphibiaTree* component will first introduce the project (David Cannatella) and then convene a forum to discuss the controversial results of recent studies of life-history evolution in urodeles. Following short presentations (Rachel Mueller, Paul Chippindale) and responses (Richard Bruce, James Hanken), audience members will be invited to participate in a vigorous discussion. We invite all meeting attendees, including those who have any interest in the study of phylogeny and evolution, to attend this free-flowing, unusual, and likely memorable workshop.

HANSKNECHT, KERRY A.

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The lingual lure of the Mangrove Saltmarsh Snake *Nerodia clarkii compressicauda*

The performance of caudal luring by snakes has been well known for some time, but evidence of other forms of snake predatory luring is only recently coming to light. Based on the behavior of more than 20 individuals, I will describe the use of the tongue as a lure by Mangrove Saltmarsh Snakes as a means to attract fish prey. Video sequences will be provided as evidence and example of the behavior and its effectiveness. Analysis of lures by 18 individuals indicates that when using the tongue to lure (extended with the tongue tip curled upon itself), snakes keep the tongue extended significantly longer than when performing typical chemosensory tongue flicks. In addition, there is considerable variation in the duration of lures both between and within individuals.

***HARLIN-COGNATO, APRIL D.; HOFFMAN, ERIC A.; JONES, ADAM G.**

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Brood pouch genomics: Novel gene function associated with male pregnancy in pipefishes and seahorses (Syngnathidae)

Evolutionary novelty provides unique opportunities to explore the genetic underpinnings of morphological innovation. In this study, we examined the genetic basis of a unique morphological trait, male pregnancy in syngnathid fish. In seahorses and their pipefish relatives, a female uses an ovipositor to transfer her unfertilized eggs to a brood pouch on a male. The male fertilizes the eggs within the pouch and provides nutrients, osmoregulation, and oxygenation to the embryos through a placenta-like connection. Hence, the syngnathid fishes are the only taxa in which true male pregnancy is recognized. Our primary goal was to determine which genes are co-opted by males for pregnancy, with future goals to investigate the evolutionary history of these genes. We synthesized cDNA from RNA extracted from brood pouch tissue from four pregnant and four non-pregnant *Syngnathus scovelli* collected from the Florida gulf coast. We conducted suppression subtraction hybridization (SSH), whereby we sought to isolate genes only expressed in pregnant pipefish. From this procedure, we obtained a cDNA library of subtracted genes, from which 6 putative candidate genes were isolated. Of these candidate genes, we have evidence from qRT-PCR that a nephrosin-like protein from the zinc-dependent metallo-protease family is expressed in pregnant male pipefishes. Examination of the structure of our protein revealed a close evolutionary relationship to other proteins involved in the breakdown of the egg chorion prior to the hatching of embryos in fishes and other vertebrates. From these results we present the evolutionary implications of the co-option of a choriolytic-type enzyme in male pregnancy. Additionally, we present preliminary data on other candidate genes and discuss their potential function in the maintenance and regulation of the brood-pouch structure and

embryo gestation.

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A new species of *Creagrutus* (Teleostei: Characidae) collected during the 2004 Trans-Continental Catfish Expedition to Peru

During the Trans-Continental Catfish Expedition to Peru (TCEP), July - August, 2004, five species of *Creagrutus* were collected, some of them at high elevation in the Andes. The material is identified as *Creagrutus manu*, *C. pila*, *C. ouranonastes*, *C. peruanus*, and an undescribed species, *Creagrutus* n. sp. A. Of these species, *C. ouranonastes*, *C. peruanus* and the undescribed species are most similar with respect to reduction in the width of the infraorbital series and, possibly derived, lack of fin-ray hooks and the presence of a gap between the first two premaxillary teeth. The new species differs from these other species and nearly all other *Creagrutus* species in the presence of very well developed papillae extending posterior of the head over the predorsal surface, and from all other described congeners in the very dark, nearly black, pigmentation covering much of the body and fins in adults. The dark pigment is also present in subadults but it is distributed much less extensively on the lateral surfaces of the body. The new species is most similar to *C. peruanus* with respect to overall body form and meristic characters. Although the elevational ranges of *C. peruanus* (642-2285 m) and *Creagrutus* n. sp. A (444-1155 m) overlap, they were collected together at only one site, and *C. peruanus* was recorded at a much higher elevation than the new species, suggesting ecological differences between these similar forms.

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Assessing amphibian population declines in an African biodiversity hotspot

Amphibian population declines are well documented in the United States, Australia, Central America and South America, but the status of most African populations is unknown. Monitoring of amphibian populations is especially important in Africa's biodiversity hotspots such as the Eastern Arc Mountains of Tanzania and Kenya. In these areas of high endemism, extinction of a local population can easily result in the extinction of an entire species. It is not only the high biodiversity and endemism of the Eastern Arc that deems it a conservation priority, but also the intense pressures of mining, deforestation and development. In addition to habitat destruction, amphibians of the Eastern Arc are experiencing most of the threats cited as possible causes of the global decline of amphibian populations including chemical pollution from agriculture, global climate change, and the pathogenic fungus *Batrachochytrium dendrobatidis*. Conserving amphibian biodiversity when faced with the dual threats of habitat

destruction and disease will require active management plans, without which extinctions will continue to occur. Biodiversity surveys are an important first step in amphibian conservation but surveys alone will not prevent extinctions. Efforts to conserve the amphibian diversity of the Eastern Arc Mountains will require a multi-stage approach including: (1) Inventory of amphibian biodiversity (2) Monitoring of local amphibian populations (3) Implementation of appropriate management plans to reduce extinction risks. Biodiversity inventories have been carried out in many of the forest reserves within the Eastern Arc and many more surveys are scheduled to be completed within two years. Our next challenge will be to use these baseline data as a starting point for longer term population monitoring and the development of appropriate management plans.

***HARPER, GEORGE R.; PFENNIG, DAVID W.**

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The role of gene flow in a coral snake mimicry system: The phylogeography of scarlet kingsnakes

A critical prediction of Batesian mimicry theory is that protection from predators should break down where the dangerous model is absent, because predators would not be under selection to avoid the model or any other species that resemble it. Previous research shows that predators avoid replicas of the Scarlet kingsnake (SKS) (*Lampropeltis triangulum elapsoides*) where coral snakes occur, however predators preferentially attack replicas of SKS where coral snakes do not occur. Selection against the mimetic pattern could be overcome by gene flow from areas where the pattern is favored to areas where it is maladaptive. We conducted a number of phylogeographic analyses of both mitochondrial DNA and nuclear DNA to look at the genetic population structure of SKS and to determine whether there is sufficient gene flow to overcome selection against the mimetic pattern.

***HARPER, GEORGE R.; ZIMMERER, ED; GROGAN, WILLIAM L.; OWENS, JANINE; PFENNIG, DAVID W.**

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A re-evaluation of the taxonomic status of the Scarlet Kingsnake, *Lampropeltis triangulum elapsoides*

The taxonomic status of scarlet kingsnakes (SKS) (*Lampropeltis triangulum elapsoides*) has long been debated. Williams (1978) placed SKS within *L. triangulum* based mainly on the assumption that they intergrade with eastern milksnakes (EMS) (*L. triangulum triangulum*) and produce coastal plain milksnakes (CPMS) (nee *L. triangulum temporalis*) along the coastal plain from North Carolina to New Jersey. We re-evaluated the status of SKS using molecular characters as well as biogeography. We compared data from SKS and three

subspecies of *L. triangulum* (*L. t. triangulum*, *L. t. sypila* and *L. t. amaura*) that are either sympatric with or have adjoining ranges with SKS. We also compared the data to four other members of *Lampropeltis* (*L. getula*, *L. mexicana*, *L. pyromelana* and *L. zonata*) in order to determine where SKS fit within the genus. Our results indicate that the scarlet kingsnake is not a member of *L. triangulum* and we recommend that it be recognized as the distinct species, *L. elapsoides* (Holbrook 1838).

HARRINGTON, RICHARD C.

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Diet diversity in the adaptive radiation of darters

Darters are one of the most species-rich groups of North American freshwater fishes, and likewise exhibit a diversity of adaptations for a variety of aquatic habitats. This radiation has received considerable attention from a systematic perspective using both morphological and molecular phylogenetic methods, but comparative methods have not examined other axes of variation, such as diet and habitat use. Feeding behavior and diet are important components of life history analyses and thus can potentially provide important insights into ecological aspects of diversification in the adaptive radiation of darters. The last comparative review of diet variation among darter species was published in the 1880s, and since then a large number of species have been described and quantitative gut content analyses performed. We have compiled gut content analysis data from darter life history accounts of more than 70 species, covering the gamut of all major darter phylogenetic groups. With this diet data and a nearly completely sampled species-level molecular phylogeny, we are developing a phylogenetically correct comparative analysis for characterizing the degree of dietary overlap among darter species and clades and exploring correlations between diet and phylogeny, while also testing previously held notions that morphological disparity and geographical patterns of speciation are important factors in the adaptive radiation of darters. **STOYE ECOLOGY & ETHOLOGY**

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Phylogenetic relationships of the tribe Moxostomatini (Catostomidae) based on nuclear S7 ribosomal protein gene sequences

A recent phylogenetic study by Harris et al. (2002) based on complete mitochondrial cytochrome *b* gene sequences subsumed the genus *Scartomyzon* (jumprock suckers, c. eight-10 species) into *Moxostoma* (redhorse suckers, c. 10-11 species). While this study advanced our understanding of relationships among some species within *Moxostoma*, genealogical affinities among several lineages within this genus remained unclear. To further examine phylogenetic relationships among moxostomatini suckers, complete sequences from the first

intron of the nuclear S7 ribosomal protein gene were obtained from 43 species within this tribe and representative outgroup taxa from the Catostomini and other catostomid subfamilies. Phylogenetic analysis of the S7 sequences yielded a monophyletic *Moxostoma*, with many of the same species groups as that recovered by the cytochrome *b* gene sequences. Concordant with Harris et al. (2002), *Scartomyzon* was never resolved as monophyletic, but was always recovered as a polyphyletic group embedded within *Moxostoma*. Relationships among moxostomatine lineages were generally consistent with previous phylogenetic hypotheses of relationships within this tribe.

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Inhibition of pathogenic fungi by cutaneous bacteria of salamanders *Hemidactylium scutatum* and *Plethodon cinereus*

Amphibian skin hosts a diverse microbial flora. Some bacterial species produce antibiotics as a mechanism of interference competition. These antibiotics can inhibit pathogenic fungi that attack amphibian eggs and chytrid fungi that attack amphibian adults. The objectives of this study were to (1) characterize the cutaneous antifungal bacterial flora of two species of plethodontid salamanders, *Hemidactylium scutatum* and *Plethodon cinereus* and (2) test for an association of nesting behavior in *H. scutatum* (solitary or joint) and bacterial status (antifungal bacteria positive or negative). Brooding *H. scutatum*, and probably all other plethodontids, weave among their eggs, which can impart antibiotics from bacteria and antimicrobial peptides to their eggs. Individuals of both species were washed with sterile dechlorinated water to remove transient bacteria from the skin. Swabs of the salamanders were streaked out on low nutrient R2A medium and incubated. Pure colonies were established, and each bacterial morphospecies was challenged with several fungi, including an ascomycete related to the genus *Gliocladium*, which we have shown is pathogenic to salamander eggs. Almost all individuals of *P. cinereus* and about one third of *H. scutatum* harbored antifungal bacteria. Antifungal bacteria were identified by sequencing the 16S RNA gene and included phylogenetically diverse genera, such as *Lysobacter*, *Pseudomonas*, *Chryseobacterium*, and *Bacillus*. Preliminary data from collaborators at Duke University indicate that some of our bacterial isolates inhibit *Batrachochytrium dendrobatidis* in vitro. A field survey of joint and solitary nests of *H. scutatum* revealed that individuals positive for antifungal bacteria were significantly more likely to be associated with joint nests. Joint nesting may act as a mechanism to increase the likelihood of at least one female being harboring antifungal bacteria at a nest. Amphibians may exploit and facilitate interference competition among their cutaneous bacterial flora as a means of protecting their eggs and themselves from pathogenic fungi.

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Patterns in the herpetological diversity of lowland Neotropical rainforest:
A macroecological perspective

Although many herpetological surveys have been conducted in the Neotropics, few studies have used these data to examine macroecological patterns in herptile diversity. Herpetological data from 12 lowland neotropical rainforest sites were analyzed for patterns of local and regional diversity. Herptiles were collected at the Reserva Nacional Allpahuayo-Mishana, northeastern Peru, during 1997, 1998, and 2001, in disturbed and undisturbed forest. Shannon's diversity and evenness indices were calculated for the herptile communities in each habitat. These indices indicated a more diverse and even community in undisturbed habitat. Composition also differed between sites, with more habitat specialists found in primary forest. To examine patterns in regional diversity, presence/absence data were used to calculate Jaccards similarity index at 12 neotropical sites. The relationship between faunal similarity and geographic proximity was tested with a Mantel test and found to be highly significant. Based on UPGMA cluster analysis, sites clustered into four geographic subregions, similar to the pattern found for other taxonomic groups, specifically volant and non-volant mammals. These data were then incorporated into an interpolative GIS model to better visualize macroecological patterns of herpetological distribution.

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Design and performance of a novel wet operative temperature
thermometer for amphibian habiat evaluation

New type of a wet physical model that mimics frog body temperature is proposed and was tested for their performances in the field. Material is a piece of sponge made of form phenol synthetic resin commercially developed for flower arrangement. By measuring temperature profiles of the sponge models, water contents of the sponge that can be realistic substitutions of actual frogs were determined to be 60-70% This sponge model exhibited temperature profiles very close to those of actual frogs (*Rana japonica*) of comparable size under ambient temperature normally experienced by the frogs in the field. High water absorption capabilities, toughness and right weight of the sponge merit use in the field in large numbers, being more practical, than the previously used materials such as agar, plaster and formalin fixed specimens.

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Allopatric speciation in chaenopsid blennies - another new species of *Acanthemblemaria* from the tropical eastern Pacific

Although the systematics of chaenopsid blennies has been studied extensively, new species continue to be discovered and described. This is especially true for the barnacle blennies of the genus *Acanthemblemaria*. Myers and Reid described the first species, *Acanthemblemaria hancocki* from Panama, in 1936, and this was soon followed by Brock's 1940 descriptions of *A. balanorum* and *A. hancocki macrospilus* (elevated to full species status by Stephens in 1963) from Mexico. Since then, five more species have been named including *A. rivasi* Stephens, 1970 from the southern Caribbean, and a series of island endemics: *A. castroi* Stephens & Hobson, 1966 from Islas Galápagos, *A. stephensi* Rosenblatt & McCosker, 1988 from Isla Malpelo, *A. atrata* Hastings & Robertson, 1999 from Isla del Coco and *A. mangognatha* Hastings & Robertson, 1999 from Islas Revillagigedo. Recent analyses of 16s sequence data for *A. macrospilus* reveal significant genetic divergence (approximately 3 %) between populations from the Gulf of California and coastal Mexico south of the Gulf. This genetic break coincides with distinctive color morphs in the region except for specimens from Isla Isabela that have genetics similar to adjacent mainland populations but a color pattern superficially resembling Gulf populations. With the exception of the widespread *A. balanorum*, distributions of TEP barnacle blennies are allopatric and coincide closely with previously designated biogeographic provinces. A morphology-based phylogenetic hypothesis supports the importance of habitat gaps (both open water and stretches of coastline largely devoid of rocky substrate) in allopatric speciation in these small reef fishes.

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Population genetic structure of the European fire-bellied toad (*Bombina orientalis*)

The fire-bellied toad has a wide distribution in Northern and Eastern Europe, occurring as far north as Denmark, as far west as the state of Schleswig-Holstein in Germany, as far east as Lithuania, and as far south as the Carpathian mountains. The drastic population decline in many parts of its range has been associated with fragmentation and loss of appropriate aquatic and terrestrial habitat (shallow breeding ponds in extensively grazed meadows and larger foraging ponds surrounded by sheltered hibernating sites). Intensive agricultural practices have also been linked to the population decline of *Bombina orientalis*, as it inhabits agricultural areas and adult frogs in particular are vulnerable to intense spraying of pesticides. As part of a conservation strategy plan, we are currently using nine microsatellite loci to unravel the genetic structure of this species on a local and larger geographic scale, to estimate genetic exchange among

populations, and to detect potentially inbred populations. We are using samples collected from Denmark, Germany, and Poland. The results of this study will be used for management actions such as denomination of suitable source populations for release and translocation efforts. We acknowledge financial support of the European Commission, the Stiftung Naturschutz Schleswig-Holstein, and the Landesamt für Natur und Umwelt Schleswig-Holstein.

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The effects of forestry management on the distribution and abundance of amphibians

The effects of forestry management on the distribution and abundance of amphibians have not been quantitatively assessed over long time periods, with most studies lasting only one to two years post-logging. This investigation occurred ten years post-logging and is the first attempt to evaluate the longer-term effects of specific forestry management practices on amphibian communities in western Washington State. Terrestrial amphibian populations were sampled from 17 sites with three treatments (control, modified, and state) using pitfall trapping and hand-catches from spring 2003 through fall 2004. I used a paired sampling design to assess differences in abundance and distribution between riparian and adjacent upland transects. In total, 1,124 individuals of 13 species were captured, marked and released. Abundance did not differ for most species between transects or treatments; however, one species (*Ensatina eschscholtzii*) was found more frequently on upland transects ($p = 0.0020$). The abundance of *Ascaphus truei* was higher at control sites ($p = 0.0386$), while the abundance of *Taricha granulosa* was higher at modified sites, which had wider riparian buffers ($p = 0.038$). However, the factors responsible for these effects have so far remained elusive as I have found no evidence of strong correlations between habitat attributes and occurrence of any species at the treatment, transect, or site levels. A Principal Components Analysis was used to assess habitat differences among sites and the data suggest that site (not regional) characterization will likely be important when considering management for amphibians. For example, management prescriptions developed for a particular site may be applicable to other sites within the same watershed, but not across landscapes or regions. **SSAR SEIBERT ECOLOGY**

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Restoration potential for red-legged frogs (*Rana aurora aurora*) in an impounded watershed

In British Columbia (BC), the Red-legged frog is considered threatened and federally it is a COSEWIC (Committee on the Status of Endangered Wildlife in Canada) Species of Special Concern. One the largest threats to this species in BC is habitat loss, especially the loss of wetlands and small ponds suitable for breeding. Large scale forestry, mining, and incremental human development

have all been indicated as causal agents leading to the loss of wetland habitats. Large-scale habitat loss is also related to hydroelectric developments and the impoundment of river systems and associated wetlands. This study assessed the availability and distribution of Red-legged frog breeding habitat in the Jordan River watershed on southwestern Vancouver Island, BC. Pre-impoundment (1908), the footprint area contained approximately 134.4 ha of suitable breeding habitats, including several large wetlands. As a result of impoundment, approximately 90 ha of suitable wetlands were inundated and an additional 7 ha will be lost in 2005, leaving only 36% (46.2 ha) of the original 134.4 ha available to frogs for breeding. Field surveys in 2004 and 2005 confirmed Red-legged frogs are still present and breed in affected habitats in the watershed. Daily water fluctuations in each reservoir during the period of egg deposition and hatching (20 Feb through 01 May) preclude breeding. To mitigate for the net loss of suitable breeding habitat, a restoration initiative is being considered that involves the construction of perched wetlands and development of foreshore habitats within the two main reservoirs where as much as 53 ha of wetland habitat could be created.

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Custom trucks, radio snake jingles, and temporary tattoos: An overview of a successful public awareness campaign related to brown treesnakes in the Commonwealth of the Northern Mariana Islands (CNMI)

The brown treesnake (*Boiga irregularis*) was introduced on Guam during post WWII cargo movements and has since become a serious pest. In the absence of natural population controls and abundant prey on Guam, the brown treesnakes (BTS) have now become an exceptionally common pest causing major ecological and economic problems on the island. The CNMI is often considered the highest risk extralimital site for a BTS introduction due to its close proximity and the type/amount of Guam-based cargo received. Limited brown treesnake awareness efforts between 1986 and 2002 resulted in a less than effective rapid response effort by the CNMI Division of Fish and Wildlife (DFW) Staff. 66 credible snake sightings reported between 1986 and 2002 had an average response time (time from when the snake was sighted and when DFW responded) of 126 hours. The lack of immediacy in reporting the snake sighted was a common problem, indicating that an increased awareness effort was needed. An awareness plan was therefore outlined in three phases: 1) baseline public survey, 2) nine month awareness campaign based on survey results, and 3) evaluation survey. DFW staff, together with a professional advertising firm, created a baseline survey to gather media consumption information and environmental attitudes. Conclusions of the baseline survey were then utilized in creating the nine month multi-faceted awareness campaign to improve snake sighting response efforts. A limited campaign budget forced DFW to solicit support from the private sector resulting in a sole sponsorship from Verizon Micronesia. After the nine month campaign, snake sighting reports decreased from 126 hours to 2 hours 9 minutes. Immediately following the nine month effort an evaluation survey was conducted that confirmed the success of the

campaign. The survey work continues to drive the awareness campaign which in 2004 averaged a 12 minute rapid response effort.

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Composition and ecological similarity of amphibian communities in modified habitats in the canal zone of Panamá

Despite the prevalence of exotic monocultures in neotropical landscapes, their impacts on local animal diversity are incompletely understood. Species residing in monocultures may be a nonrandom subset of the local fauna with phylogenetic or life history similarities. Amphibian richness and abundance were quantified in teak *Tectona grandis*, paja blanca *Saccharum spontaneum*, and secondary forest habitats in the canal zone of Panamá. Diurnal and nocturnal visual encounter and vocalization surveys were conducted along aquatic and terrestrial transects in each habitat. To describe the microhabitat of each transect, temperature, relative humidity, and percent canopy cover were measured. Eighteen species were encountered in the three habitats. Transects in aquatic forest habitats had the greatest species richness, with 12 species from seven families. In contrast, only four species from two families were encountered in the terrestrial teak and aquatic paja blanca habitats. Members of the Leptodactylidae were dominant in the teak and paja blanca. In addition, diurnally active species were absent from the monocultures. Species richness was positively correlated with amount of canopy cover, low diurnal temperatures, and high relative humidity. These results suggest that monocultures of teak and paja blanca support fewer species than secondary forest and that the species are a nonrandom subset of the local amphibian fauna.

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South American *Eleutherodactylus* form a large and ancient clade of frogs

The genus *Eleutherodactylus* is by far the largest among terrestrial vertebrates, with over 750 described and numerous undescribed species. In the past, phylogenetic relationships among species have proven difficult to resolve, especially within South America where most species occur. Recently, however, molecular data have been used to explore these relationships and define clades. Here we present results of phylogenetic analyses of South American species of *Eleutherodactylus* using sequences of the genes for 12S and 16S ribosomal RNA. Our results indicate that many or most South American *Eleutherodactylus* belong to a single large radiation encompassing a number of recognized species groups, with biogeographic implications.

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Nutrient theft by the cestode macroparasite *Schistocephalus* and clutch characteristics of threespine stickleback

We investigated the effects of the cestode macroparasite *Schistocephalus solidus* on clutch size and egg size in female threespine stickleback *Gasterosteus aculeatus*. Our study showed that parasitic infection may reduce both egg size and clutch size. Additionally, the reductions in these life history traits are correlated with the ratio of parasite mass to host mass. Our results suggest that nutrient theft by the parasite is driving the changes in both traits.

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Microhabitat use of tiger sharks in Shark Bay, Western Australia:
Predator-prey interactions at multiple spatial scales

Tiger sharks (*Galeocerdo cuvier*) are important predators in a variety of nearshore communities, including the seagrass ecosystem of Shark Bay, Western Australia. Growing evidence suggests that they may have profound impacts on the habitat use decisions made by a variety of prey species in Shark Bay, but the possibility that these effects occur over multiple spatial scales has not been investigated. We used catch rates and acoustic tracking to determine tiger shark microhabitat use, and conducted surveys of bottlenose dolphin (*Tursiops aduncus*) distribution and captures of green sea turtles (*Chelonia mydas*) to assess their responses to predation risk. Sharks preferred shallow habitats over deep ones, but preferred shallow edge microhabitats over shallow interior ones. The use of shallow edges likely increases encounter rates with potential prey, but prey are more likely to escape an encounter with a tiger shark in these microhabitats than they are within interior ones. Interestingly, turtles with good body condition and dolphins select edge microhabitats over interior ones when tiger sharks are present. This suggests that intrinsic habitat risk (probability of death in an encounter situation) is more important than shark density in determining microhabitat use of prey. The dynamics of predator-prey interactions over multiple spatial scales in Shark Bay may have important consequences for the dynamics of the Shark Bay seagrass ecosystem through indirect effects transmitted by grazers, like green turtles, that are common prey of tiger sharks.

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Truchas Mexicanas: New discoveries and insights into diversity and conservation status of Mexico's native trouts

Our growing bi-national 'Truchas Mexicanas' team continues exploring northwest Mexico's Sierra Madre Occidental (SMO). Undescribed native trouts have long been known from the northern rios Yaqui and Mayo, and the only formally described mainland Mexico trout (*Oncorhynchus chrysogaster*) occurs in the next Pacific drainages to the south; rios Fuerte, Sinaloa and Culiacán. Further southward, specimens from rios Presidio and San Lorenzo, previously considered non-native or of uncertain status, are native according to our preliminary genetic and morphological work, and new native forms were discovered even further south in the Baluarte and Acaponeta basins. We also recently collected the first vouchered specimens of a native trout from the Rio Conchos (Rio Grande) drainage. Desktop GARP modeling of native trout habitats based on known localities and remotely sensed data focused searches for new localities, and indicated potential trout habitat extending well beyond areas sampled to date. Preliminary analyses of mitochondrial and nuclear DNA sequence data support several recently derived but distinct Mexican lineages conflated with *O. mykiss*, and a phylogenetic placement of *O. chrysogaster* that renders *O. mykiss* paraphyletic. Morphology and microsatellite DNA reveal introgression with non-native Rainbow Trout (*O. mykiss*) in many areas, but also existence of pure stocks of each native form. All Mexican trout species are endangered by escape of hatchery rainbows from rapidly expanding aquaculture, and IPN-exposed rainbows were recently shipped to hatcheries within ranges of native trouts. Habitat degradation is common throughout the SMO, and all Mexican trouts are susceptible to climate change. Team members continue to work with Mexican government officials and local residents promoting native trout conservation by increasing awareness, pointing out risks posed by many human activities, and researching adaptability of native stocks to aquaculture. Our fieldwork and genetic and morphological analyses continue

focusing on describing new taxa, evolutionary histories and conservation status.

***HENNING, MARCY L.; SHIVJI, MAHMOOD S.**

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Streamlined genetic identification of ridgeback sharks for fisheries management and conservation

The burgeoning market for shark products, including high demand for shark fins, has raised widespread concerns about ecologically harmful exploitation of many shark species, and prompted calls for better management and conservation of sharks on a species-specific basis. Despite the desired goal of species-specific management, the U.S. Atlantic shark fishery is currently managed on the basis of species groups mainly because of difficulties identifying many of the requiem sharks (family *Carcharhinidae*) common in the fishery. We report a highly streamlined, rapid multiplex PCR method for identifying ridgeback carcharhinid shark carcasses and other body parts to species level. Our multiplex PCR assay comprises eight species-specific nested in between two universal primers simultaneously to discriminate the seven ridgeback sharks (night [*Carcharhinus signatus*], dusky [*C. obscurus*], Caribbean reef [*C. perezi*], sandbar [*C. plumbeus*], bignose [*C. altimus*], silky [*C. falciformis*], and tiger [*Galeocerdo cuvier*]) in U.S. and global commercial fisheries. The primers are designed based on fixed, species-specific variations in the nuclear ribosomal ITS2 locus. Assessment of intra-specific DNA sequence variability in this locus on a global scale indicates extremely high conservation within species, making the ITS2 locus very useful for potential shark DNA barcoding applications. Use of this assay to screen fins from the Hong Kong market reveals the presence of fins from most of these ridgeback species in the international fin trade.

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Boys will be boys: Sexual conflicts in captive sand tiger sharks, *Carcharias taurus*

Precopulatory behavior in captive sand tiger sharks, *Carcharias taurus*, has previously been documented. Reproductive behavior or sexual conflicts were documented from 1998 to 2003 in a colony of sand tiger sharks at the National Aquarium in Baltimore. These observations corroborate much of the previous information. Of note however, is that the dominance hierarchy in males is associated with additional behaviors not previously described. Physical separation of males resulted in a cessation of sexual conflicts. The results suggest that in this colony at least the dominance hierarchy in males is not based strictly upon size, the speed and food intake patterns are indicative of position in the hierarchy, and that the most dominant and most subordinate males are key sharks within the hierarchy.

HESTER, JOY M.

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Effects of relocation on movements and home ranges of eastern box turtles
(*Terrapene carolina*)

Eastern box turtle (*Terrapene carolina*) populations are threatened by expanding urbanization, the resulting loss of habitat, and the introduction of threats such as roads, railroads, and pets. Individual box turtles are often captured by humans and relocated substantial distances from their capture location. Additionally, relocating populations of box turtles to a less threatening environment has been suggested as a possible conservation strategy. However, previous studies examining the effects of relocation on box turtles are limited. Thus, we compared the home ranges and movement patterns of resident and relocated box turtles. We radio tracked ten relocated and ten resident female box turtles on the Davidson College Ecological Preserve, in Davidson, NC. All turtles were tracked twice weekly during the active season beginning in May 2004. Geographic coordinates were recorded during each tracking session. Results suggest that the majority of relocated box turtles have larger home ranges and move longer distances than resident box turtles. Additionally, relocated turtles had higher mortality and disappearance rates than resident turtles. Our preliminary results indicate that relocated box turtles do not quickly reestablish home ranges in a new habitat, and may attempt to leave their relocation site, thus raising questions about the success of relocation as a conservation strategy for eastern box turtles.

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Can MPAs be effective for managing a mobile shark population?

The presence and movements of a population of young blacktip sharks (*Carcharhinus limbatus*) was monitored via a series of acoustic hydrophones over a period of three years to examine their use of a coastal nursery area. Data from this project were used to investigate the efficacy of hypothetical marine protected areas (MPA) for this population. Small and large reserve designs were used to determine which would provide better protection for this population. The small reserve (c. 1.5 km²) provided consistent levels of protection across years with sharks receiving good protection early in the summer season, but with declining protection thereafter. The large reserve (c. 3.5 km²) provided less consistent levels of protection across years, but provided protection for a greater portion of time than the small reserve. Excursions from the small reserve were high early in the season and declined as sharks used this region less through the later portion of the summer. Excursions from the large reserve did not show any consistent pattern, but were also high early in the season and decreased through time as sharks used less of the reserve area. These results were coupled with previously calculated mortality estimates to examine whether these reserve areas provided reliable protection for sharks during their periods of highest mortality. The large reserve provided better protection for sharks during this period than the small reserve, suggesting the large reserve design may have provided sufficient protection for young sharks. Although there are currently no protected areas

directed at shark nurseries, these results suggest that time-area closures for nursery populations of highly mobile shark species may be of value. Directed MPAs may be useful for mobile populations during select times of their life history or in select locations along their migratory routes.

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Venom of the Brown Treesnake: Biological role of irregulin, a CRiSP venom protein

Venoms are complex secretions which represent one of the most important components of the chemical ecology of advanced snakes. Among the many components known from venoms are cysteine-rich secretory proteins (CRiSPs), a recently described but poorly known protein family. Previous work in our laboratory resulted in the isolation, purification and cloning of irregulin, a CRiSP from the venom of the Brown Treesnake (*Boiga irregularis*). Additionally, we have found CRiSPs to be broadly distributed in the three major families of venomous snakes (Colubridae, Elapidae and Viperidae), and all venom proteins sequenced to date have a high degree of sequence identity. Recent work has focused on determination of the activity and biological role of irregulin, particularly in terms of effects during envenomation and on predator-prey interactions. Many of the proteins from the CRiSP family have poorly defined or unknown activities, and the role of irregulin has been similarly difficult to ascertain. *In vitro* assays of activity eliminated many possible functions, and toxicity studies with purified irregulin, in several different animal models, demonstrated that this protein is apparently non-toxic even at relatively high doses. However, several proteins from the CRiSP family have been shown to induce hypothermia in mammalian prey, and we examined the induction of hypothermia using irregulin in model organisms. Based on venom toxicity studies, which showed that Brown Treesnake venom is of low toxicity to mammals, we focused our efforts on a lizard model. A significant effect on the thermoregulatory behavior of the curious skink (*Carlia aylanpalai*) was observed following injection of irregulin. This species is an important prey for Brown Treesnakes on Guam, and we suggest that interference with thermoregulation, particularly in conjunction with other venom toxins, facilitates handling of lizard prey. These results demonstrate that the trophic roles of specific venom components extend beyond simple acute toxicity.

***HIERLIHY, CATHERINE A.; MALLORY, FRANK F.; COLLAZO, RODOLFO G.**

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Diet composition and trophic morphology dimorphism in the iguanid lizard *Sceloporous siniferus* from Huatulco, Mexico

Two hypotheses proposed to explain the evolution of sexual size dimorphism are

sexual selection and intraspecific niche divergence. The sexual selection hypothesis has been well supported by many studies, whereas the niche divergence hypothesis has received little attention and little support. Intraspecific niche divergence may occur when the sexes differ in nutritional or habitat requirements, both of which can lead to dietary differences and dimorphisms in trophic morphology. The current study used analyses of diet composition and trophic morphology to look for evidence of niche divergence in the iguanid lizard *Sceloporus siniferus* from Huatulco, Mexico. Results indicated that there is male biased sexual size dimorphism in this species in both weight and snout-vent length, which is likely the result of sexual selection. Females had a relatively larger gastrointestinal system and a different diet composition than males. The presence of the larger gastrointestinal system in females may reflect adaptation to increased nutritional requirements of reproduction or to habitat divergence. Habitat divergence is supported by the fact that male diets contained an arboreal Family of termites that was not present in female diets. The presence of dimorphism in trophic morphology and diet composition provides support for the hypothesis that intraspecific niche divergence occurs in *S. siniferus*. Therefore, the niche divergence hypothesis concerning the evolution of sexual size dimorphism may have greater application than once believed.

HILBER, SAMANTHA A.

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Egg size through successive spawnings in the Convict Cichlid

Many fish lay eggs multiple times in their life, but not all eggs are the same size. There are costs and benefits for each size of egg. For example, larger eggs take longer to develop but become larger hatchlings, which can swim better in fast-flowing water. Theory predicts that a female should make eggs of the particular size which best resolves this trade-off, then she should produce as many eggs of that size as she can according to the resources available. However, anecdotal observations suggest that females do not always follow this prediction. By carefully spawning a group of convict cichlids (*Archocentrus nigrofasciatus*), I was able to examine eggs in the first five clutches of 12 females. I found that the number of eggs in a clutch increased as female body size increased. I also found that over five successive clutches mean egg size decreased and the variance of egg size did not exhibit a pattern. This indicates that when females are young they are operating under a different trade off than more mature females. **STOYE ECOLOGY & ETHOLOGY**

***HILDEBRAND, HEATHER L.; WELSH, STUART A.**

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Environmental cues to upstream migration of *Anguilla rostrata* in the lower Shenandoah River, upper Potomac River drainage

Available data depict declines in abundances of American eel populations. Little information exists on abundances and movements of yellow-phase eels in upper watersheds, and on impacts of dams to upstream migration. Eel ladders on dams

provide both a relatively low cost solution to upstream passage and the opportunity for managers to collect data on upstream migrants. An eel ladder was installed during early summer 2004 at the Millville Dam, lower Shenandoah River, West Virginia. During summer and fall 2004, we collected daily information on eels (counts, weights, and total lengths) and environmental variables (lunar phase, river flow, water temperature, and local precipitation). Models with environmental covariates were fit to the time series of daily count data and selected with Akaike's information criterion. During summer and fall 2004, a total of 3548 eels (range 200 to 690 mm TL) passed the Millville ladder. The best approximating models to the count data included lunar phase and river flow. During summer and fall, higher daily counts of eels occurred with both spikes in river flow and dark periods of the new moon. Large numbers of upstream migrant eels during fall and summer provide baseline data for future assessments, and indicate that upstream migration within the upper Potomac River drainage occurs across multiple seasons.

***HILER, WAYLON R.; WHEELER, BENJAMIN A.; TRAUTH, STANLEY E.; CHRISTIAN, ALAN D.**

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Trophic interactions and abnormalities of a species in decline, the Ozark Hellbender (*Cryptobranchus alleganiensis bishopi*)

Since the early 1980's the Ozark hellbender, North America's largest salamander, has undergone a steady decline throughout its entire range. Two rivers in Arkansas known to have populations of hellbenders are the Eleven Point and Spring (SR) rivers. Ozark hellbenders from the SR have undergone the most drastic population decline witnessed within their range over the past 20 years. Shifts in benthic habitat and community compositions could influence these declines, which in turn could affect the species composition of their primary prey item, the crayfish. By linking stable C and N ratio results and relative abundances of crayfish we sought to identify species-specific trophic relationships of hellbenders and crayfish. Furthermore, SR hellbender tissue samples were collected from museum specimens deposited in the early 1970's which were then analyzed for stable C and N ratios. Comparisons were made with present-day data. In addition, we documented gross abnormalities in this species during the 2003-2005 sampling period.

***HILL, JEFFREY E.; WATSON, CRAIG A.**

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Diet of the nonindigenous Asian Swamp Eel, *Monopterus albus* (Synbranchidae), in tropical ornamental aquaculture ponds in Florida

The nonindigenous Asian swamp eel, *Monopterus albus*, is established in west-central Florida where it invades tropical ornamental fish production ponds. The tropical ornamental aquaculture industry in Florida is economically valuable (>

US\$42 million in 2003) and is dominated by the production of small-bodied fishes cultured at high densities in small, earthen ponds susceptible to Asian swamp eel invasion. Although there are few data, the Asian swamp eel is considered to be a voracious generalized predator that includes fish in its diet. The objectives of this study were to document the diet of Asian swamp eels in ornamental fish production ponds and to determine the economic threat posed by these invaders. We collected Asian swamp eels from four tropical ornamental aquaculture farms in Hillsborough County, Florida, from May 2004 to March 2005 using backpack electrofishing, dipnets, and seines. Additional collections will be made until June 2005. The density of Asian swamp eels on farms is low and relatively few specimens were collected (N = 55; total length 100-864 mm). About 50% of specimens lacked stomach contents and all individuals with food had small volumes. Prey items included insects, fish eggs, oligochaetes, fish, plant material, and an amphipod. Insects (mostly odonate nymphs) dominated the diet. Only five fish prey were found in four Asian swamp eels. Our results were surprising given the highly vulnerable and available prey fish found in the sampled ponds (estimated 29-57 fish/m²) and the general presumption that Asian swamp eels are voracious predators of fish. We estimate the current economic threat of Asian swamp eels to the Florida ornamental aquaculture industry to be low. We recommend that producers follow good aquacultural practices and maintain their farm berms and screens, prevent the growth of vegetation in their ponds, and keep pond sediments to a minimum.

HILL, RANDY J.

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Ground-truthing hearing measurements using auditory evoked potential techniques against behavioral conditioning in the goldfish, *Carassius auratus*

Auditory evoked potentials (AEPs) are commonly used to measure hearing thresholds in fish. However, it is uncertain how well AEP thresholds match behavioral hearing thresholds, and if obtaining evoked potential measurements in a noisy background can affect threshold levels. The hearing sensitivity of 12 goldfish were measured using both classical conditioning and AEPs in the same setup. For behavioral conditioning, the fish were trained to reduce their respiration rate in response to a 5s sound presentation paired with a brief shock. A modified staircase method was used in which twenty reversals were completed for each frequency, and threshold levels were determined by averaging the last twelve reversals. Once the behavioral audiogram was completed, AEP measurements were made without moving the fish. The same sound stimuli (pulsed tones) were presented and the resultant evoked potentials were recorded for 1,000-6,000 averages. AEP input-output functions were then compared to the behavioral audiogram to compare techniques for estimating behavioral thresholds from AEP data. Results indicate that when comparing the two most common techniques to analyze evoked potential thresholds (visually and linear regression to 0 volts), the regression produces thresholds closer to the obtained behavioral thresholds. Behavioral methods, on average, produce lower hearing thresholds than evoked potential measurements, especially at lower frequencies. The same procedure was also conducted with and without the presence of continuous background noise. In the presence of background

masking noise the AEP thresholds were lower than the behavioral thresholds at 600Hz. **STOYE PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY**

***HILL, SHANNON K.; PIERCE, BENJAMIN A.**

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The basking ecology and community structure of freshwater turtles in Central Texas

Freshwater turtles are some of the most visible aquatic vertebrates because of their tendency to bask. Basking provides a number of potential benefits to turtles, including thermoregulation, vitamin D synthesis, aiding in digestion and ectoparasite removal. One of the most common substrates for turtle basking is deadwood. Inputs of deadwood into the active river channel may be constrained by shoreline development. Disproportionate use of basking sites by freshwater turtles suggests that certain characteristics of deadwood make for more suitable basking substrates. Shoreline vegetation, urbanization, and deadwood attributes were characterized at 30 randomly selected transects along the Brazos River in McLennan Co., Texas. Replicated surveys of basking turtles were conducted in order to better define the relationship between basking site attributes and their utilization by basking turtles. Increased urbanization was associated with reduced quantities of shoreline vegetation and a reduced number of potential basking sites. Increased shoreline vegetation was positively correlated with turtle abundance. The circumference of deadwood was significantly associated with increased use by basking turtles.

***HILTON, ERIC J.; JOHNSON, G. D.**

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Developmental osteology of the caudal skeleton of *Caranx crysos*, with comparisons to other Carangidae

Ontogeny is among the most powerful criteria for identifying homologous structures and is certainly one of the most understudied in comparative studies of fishes. In this presentation we will document the ontogenetic development of the caudal skeleton of *Caranx crysos* by examining a series of cleared and stained larval and post-larval specimens. By studying ontogeny, we are able to more accurately identify some elements of the adult caudal skeleton. For instance, the presence of two epurals has been used as a synapomorphy of Caranginae (also present in the scombrodine genera *Scombroides* and *Oligoplites*, but this is considered to be a homoplasy). There are three epurals present in larvae and small post-larval juveniles (i.e., <25 mm SL) in *C. crysos* and other carangines. However, ep2 never ossifies in *C. crysos*, and does not develop beyond its initial presence. It was last found in a 25.2 mm SL specimen as a small nodule of very lightly stained cartilage cells and eventually disappears completely. Therefore, the two epurals present in the adult are best identified as ep1 and ep3. This is in contrast to other carangines examined (e.g., *Selene*), in which ep2, although rudimentary in small specimens, does ossify and appears to fuse to the proximal tip ep1 (adult = ep1+2 and ep3). In small specimens of *Oligoplites* we have found

no indication of three epurals at any stage of development. We will discuss the osteology of the caudal skeleton of carangoid fishes generally, and emphasize the importance of ontogeny in the identification of primary homology.

***HINDERLITER, MATTHEW G.; YAGER, LISA Y.; EPPERSON, DEBORAH M.; HEISE, COLLEEN D.; LEE, JAMES R.**

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Home range, movement patterns, and habitat usage of gopher tortoises (*Gopherus polyphemus*) in southern Mississippi

We examined movement patterns, home range, and burrow and habitat usage for a population of 40 gopher tortoises (*Gopherus polyphemus*) from 2002 to 2004 at the Camp Shelby Training Site in Perry County, Mississippi, USA. Radio-telemetered tortoises were tracked at eight sites; each site consisted of a ruderal grassland area surrounded by longleaf pine-dominated forested habitat. The grassland areas are used for military training by the Mississippi Army National Guard, and are therefore maintained annually by mowing during the winter. Forested areas are managed by prescribed fire on cycles ranging between two and five years, depending on rainfall, habitat condition, and resources. Almost all tortoises spent a greater percentage of their time in the grassland areas, and there was no correlation between inter-habitat movements and temporal or climatological data. During the active season, males used significantly more burrows and spent less time at each burrow than females. Males had the greatest monthly movements each year between July and September; females had the greatest monthly movements each year in June, presumably from searching for optimal nesting areas. Females had significantly longer overwintering periods than males, although the type of habitat used as an overwintering site did not differ between sexes or between years. Home range was not found to be significantly different among the eight sites or between males and females; however, unlike previous gopher tortoise studies, mean home range for females was larger than for males. One female in our study had the largest annual home range reported for a female gopher tortoise in any study.

***HO, HSUAN-CHING; PIETSCH, THEODORE W.; SHAO, KWANG-TSAO**

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The revision of deep-sea anglerfishes (Lophiiformes: Ceratioidei) in Taiwan, with descriptions of four new species

The Ceratioid anglerfishes collected from Taiwan waters are reviewed on the basis of all known material. All specimens were collected by commercial fishing boat and R/V Ocean Researcher I (ORV I), one of them was collected by R/V Fishery Researcher I. Twenty-six species in 16 genera and 9 families of deep-sea anglerfishes collected from Taiwan waters were recognized. Two of them have

been described as new previously and another four additional species were described herein as new species. Three unidentified species are also included in the species counts. Six additional specimens that could not be identified to species level due to missing characters. Four new species, *Oneirodes* sp. n. 1, *Oneirodes* sp. n. 2, *Chirophryne* sp. n., and *Gigantactis* sp. n., were different from the all previous described species in having special esca morphology and other detail characteristics. The specimens of *Cryptosaras couesii* were re-collected in this work. *Himantolophus melanolophus* represents by three specimens in Atlantic Ocean was discovered in the Pacific Ocean first time and *Rhynchactis macrothix* and *R. leptoneura* were the new records from the west Pacific.

***HO, HSUAN-CHING; SHAO, KWANG-TSAO**

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A new species of deep-sea batfishes (Lophiiformes: Ogcocephalidae) from the western Pacific

Halieutopsis bradburyae, a new species of the deep-sea batfishes genus *Halieutopsis* represents by four specimens collected from west Pacific Ocean off Taiwan and Hawaii Islands is described herein as new. The *H. bradburyae* is unique among the previous species in having bifurcated dermal spines on ventral surface; body surface of disk covered with complex tubercles, those of snout, disk edge and subopercular with 4-7 spines; lateral line scales in preopercular series 2-3, subopercular 5-6, dorsolateral branch of subopercular series 2; ventral series 1-3; tail series 8-9.

***HOENIG, JOHN M.; GEDAMKE, TODD**

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Estimating mortality from mean length data in non-equilibrium situations, with application to the assessment of Goosefish (*Lophius americanus*)

The Beverton-Holt length-based mortality estimator has received widespread use primarily due to its applicability in data-limited situations. The mean length of animals fully vulnerable to the sampling gear can be used to estimate total mortality using only basic growth parameters and a known length at first capture. This method requires equilibrium conditions because the mean length of a population will change only gradually following a change in mortality. In this study, we derive the transitional behavior of the mean length statistic for use in non-equilibrium conditions. We investigate conditions affecting the reliability of the Beverton-Holt results and then develop a new procedure that allows a series of mortality rates to be estimated from mean length data representing non-equilibrium conditions in multiple years. We then examine the goosefish (*Lophius americanus*) assessment which was criticized for its use of the Beverton-Holt estimator under non-equilibrium conditions. Using data from the 1963-2002 National Marine Fisheries Service annual fall groundfish surveys off the Northeast United States, and assuming a single change in total mortality, we estimated using the method of maximum-likelihood that total mortality of

goosefish in the southern assessment region increased from 0.31 to 0.58 yr⁻¹ in 1977. Estimates of the new mortality rate made 3 or more years after the change were relatively stable and ranged only from 0.55 to 0.71 yr⁻¹ while estimates from the standard Beverton-Holt approach were highly variable, ranging from 0.37 to 1.1 yr⁻¹. The results for goosefish in the northern assessment region showed changes in total mortality from 0.14 to 0.29 yr⁻¹ in 1978 and then to 0.55 yr⁻¹ in 1987. The new, non-equilibrium estimator allows a change in mortality to be characterized reliably several years faster than if the Beverton-Holt estimator is used.

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Lampridiform interrelationships revisited and a new gene for teleost phylogenetics

Lampridiform interrelationships have been previously hypothesized based upon morphological and mitochondrial DNA data. However, the mitochondrial data set did not include the monotypic family Stylephoridae. Tissue for this family recently became available, prompting the present molecular study. Herein, we analyze lampridiform interrelationships using nuclear genes, including one that is newly-developed. Results of this analysis will be presented with comments on the utility of the new gene for resolving higher-level phylogenetic relationships among teleost fishes.

***HOLLINGSWORTH, BRADFORD D.; WOOD, DUSTIN A.; CATO, PAISLEY S.**

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Improved housing and organization of the herpetological collection at the San Diego Natural History Museum

Over the last three years, the herpetological collection has been undergoing a whole scale renovation to improve structural facilities, alleviate overcrowded conditions, automate label production, and replace quickly degrading materials to plastics. As the project proceeds, the rehousing project has allowed for a complete inventory of our holdings and the verification of our Specify database. As the renovation started, it was soon realized that newly developed materials were superior to the existing storage methods. Originally, the intention was to identify problematic conditions and correct for them. However, spot renovation turned to a whole scale renovation when a mixture of storage systems revealed the inferior state of the original storage system. The renovation of the 3,200 skeletal specimens is 82% complete and employs newly installed steel cabinets and individual plastic containers. Likewise, as we began to correct problems found in the wet collection, we found that it was more efficient to inventory, assign a new taxonomy, check alcohol density, rehouse, and insert the new label

when large series of jars were needing improvement. Spot checking turned to a whole scale renovation. The renovation of the 63,500 alcohol and formalin preserved materials is 50% complete. Partly funded by a grant from the National Science Foundation, with substantial commitment from the Museum, the renovation project is scheduled for completion in 2006. Venders, materials, methods, and protocols will be available during the presentation of this poster.

HOLLINGSWORTH, PHILLIP R.

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**Within drainage speciation and microendemism in darters
(Etheostomatinae)**

North America contains the highest freshwater biodiversity of any temperate region in the world. Darters (Etheostomatinae) in particular, have undergone extensive lineage diversification with approximately 200 species endemic to eastern North America. Hypotheses attempting to explain geographic modes of speciation in darters and other eastern North American freshwater fish clades have focused on Pleistocene vicariant events occurring at relatively large geographic scales leading to isolation of lineages in different drainages and highland areas followed by evolutionary divergence. Biotic exchange between neighboring drainages through stream capture events is also commonly invoked. Using complete sequence data from the mitochondrial cytochrome *b* (*cyt b*) and NADH dehydrogenase subunit 2 (ND2) genes plus the nuclear S7 ribosomal intron (S7), I tested for within drainage and within highland area evolutionary divergence in the darter *Etheostoma basilare*, a species endemic to the upper Caney Fork River system in Tennessee. The mtDNA data reveals 5 reciprocally monophyletic lineages exhibiting up to 10% uncorrected genetic distances. This is among the largest amount of intraspecific mtDNA sequence divergence observed in such a restricted geographic area. Molecular divergence time analysis indicates the oldest divergence in the *Etheostoma basilare* intraspecific phylogeny is approximately 7 mya, well before the Pleistocene glacial cycles that have been hypothesized to have been major causal agents of lineage diversification in many extant North American vertebrate groups. The results suggest microendemic speciation within highland areas could have been an important mechanism in generating the abundant North American fish fauna.

STOYE GENETICS, DEVELOPMENT & MORPHOLOGY

***HOLT, DAN; JORDAN, FRANK; CHAMPAGNE, CAROLINE; JELKS, HOWARD L.**

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Marking studies of brown darters and endangered Okaloosa darters

Understanding fish movement, habitat use, and dispersal is critical in conservation and management of fish populations. Much of this research involves marking fishes so that they can be identified upon recapture. Visible

implant elastomer (VIE) is a recently developed internal mark that has been used on a variety of fishes, although little research has focused on small-sized species. Our research assessed the utility of using VIE to mark brown darters (*Etheostoma edwini*) and endangered Okaloosa darters (*E. okaloosae*). In the laboratory, 96% of brown darters retained their marks after one month and no fish died as a result of the marking procedure. Visually oriented largemouth bass (*Micropterus salmoides*) attacked brown darters with a yellow mark more often than fish with red or clear marks. However, mark color had no effect on number of brown darters eaten by largemouth bass. In the field, we marked Okaloosa darters to evaluate movement patterns after 24 hours and one month. Okaloosa darters showed relatively uniform movement upstream and downstream of the release point and very few fish switched sides. There was little difference in distance moved after one month, suggesting that Okaloosa darters have relatively small home ranges. Recapture rates differed little after a month, suggesting mortality was low. These low movement and mortality rates are striking because Hurricane Ivan hit the study area between censuses. This study demonstrates that VIE marks are useful for studying small-sized fishes, including many of the species that are imperiled due to habitat loss, sedimentation, and other threats to streams in North America. We also present data showing fin clips do not effect survival or position holding ability in brown darters.

HOPKINS, ROB

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Hybridization of *Lythrurus fasciolaris* (Cope) and *L. umbratilis* (Girard) (Cypriniformes: Cyprinidae)

The rosefin shiner (*Lythrurus fasciolaris*) and redbfin shiner (*L. umbratilis*) are common small minnow species usually exhibiting a parapatric geographic distribution. However, historical collection records indicate several areas of possible syntopy, mostly along the periphery of distributional ranges, with suspected hybridization based upon observed intermediate coloration patterns of nuptial males. Specimen from nine suspected contact areas were collected in June and July 2004 and analyzed using biometric, meristic, tuberculation, and coloration information. To reduce levels of sexual and seasonal variation only nuptial males were analyzed. Six contact areas contained populations of nuptial males with intermediate coloration and tuberculation patterns compared to parental species, putative hybrids. Data from principal component analyses of biometrics and meristics indicate that putative hybrids exhibit shape and meristic character combinations not diagnostic of either parental. Preliminary analyses strongly suggest gene flow between parental species is occurring or has historically occurred in at least six of the sampled populations. Furthermore, evidence suggests hybridization is facilitating an eastward range expansion of *L. umbratilis* through replacement of *L. fasciolaris*. **STOYE GENERAL ICHTHYOLOGY**

***HORODYSKY, A.Z.; LATOUR, R.J.; MUSICK, J.A.; DEFFENBAUGH, B.; BRILL, R.W.**

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Hearing abilities of sciaenid fishes determined via auditory brainstem response using a novel echo-cancellation algorithm

Sciaenid fishes demonstrate substantial species-specific differences in the structure and function of the auditory system, as well as sex-specific differences in vocalization. The reproductive and alarm vocalizations of these fishes are fairly well-studied, but only recently has effort been devoted to describing their auditory abilities. Electrophysiological methods, such as the auditory brainstem response (ABR) technique, have been used for rapid and unambiguous evaluations of synchronous neural activity of fishes in response to acoustic stimuli. Here, we present results from experiments using ABR techniques employing a novel active echo-cancellation algorithm to assess the auditory capabilities of sciaenid fishes including: weakfish (*Cynoscion regalis*), spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), Atlantic croaker (*Micropogonias undulatus*), and spot (*Leiostomus xanthurus*). A white noise signal was used to characterize the echos produced from any reflective surfaces in the experimental chamber, and a proprietary computer algorithm was employed to calculate the specific waveforms needed produce active echo-cancellation. The end result was the ability to present a pure tone burst to the subject in the absence of an anechoic chamber. We employed 10 ms tone bursts from 100 Hz to 1.1 kHz, in 100 Hz steps. At each frequency, sound pressure levels (SPL) were successively attenuated in 5-dB steps until recognizable and repeatable ABR waveforms were no longer produced. Our observations suggest that the auditory abilities of these sciaenid species are within the range of other hearing generalists and correlate to the dominant frequencies of their vocalizations.

***HORTON, JAQUAN M.; DEAN, MASON N.; SUMMERS, ADAM P.**

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Morphology and material properties of teleost rib bone

The material properties of cellular bone have been extensively studied, however, little is known about the material properties of acellular bone. Given that teleost fish represent nearly 65% of the total extant species within the vertebrate group and a majority of these species have skeletons comprised of acellular bone, this group represents an opportunity to investigate the material properties of acellular bone. In this study, we used the three-point bending technique to measure rib bone stiffness and hysteresis in two teleost fish species: *Myoxocephalus polyacanthocephalus* – great sculpin, and *Sebastes caurinus* – copper rock fish, using the first 12 and 9 rib elements, respectively. We found that teleost ribs are hollow cylinders of acellular bone. There is considerable variation in the stiffness values (E) along the rib series in both species; the mean stiffness was 7.03MPa in *M. polyacanthocephalus*, and 8.94MPa in *S. caurinus*. And the percent

hysteresis differed between species; the mean percent hysteresis of the rib series was 36.84% in *M. polyacanthocephalus*, and 42.23% in *S. caurinus*.

HRBEK, TOMAS

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Phylogeny of Cyprinodontiformes based on combined analysis of molecular and morphological characters

Phylogenetic relationships of Cyprinodontiformes are reexamined using a combined analysis of 1984 bp of mitochondrial DNA, 1553 bp of nuclear DNA, and 106 morphological characters. The analysis comprises 95 terminal taxa of which 90 form the cyprinodontiform ingroup and five are non-cyprinodontiform outgroups. Phylogenetic hypotheses show a high concordance with global geological history, break-up of Pangea, but contradict previously proposed phylogenetic hypotheses based on morphological data. Phylogenetic analysis of complex morphologies and associated life-histories suggests multiple, phylogenetically-independent evolutionary instances of diapausing eggs, annualism, copulatory organs, internal fertilization, live-bearing and maternal provisioning. While life-histories and morphologies appear to repeatedly evolve in ecologically appropriate circumstances, gross similarities in morphologies and in the development of these morphologies begs the question of whether the underlying developmental genetic basis of complex life-histories and morphologies evolved convergently or due to parallelism.

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The crushing bite of the water bunny *Hydrolagus colliei*

Holocephalans, the sister group to the sharks, skates and rays, have their upper and lower dentition fused into a bony beak well suited for crushing hard prey. The upper jaw is not free, as in elasmobranchs, but fused to the cranium, providing mechanical stability during feeding. These morphological novelties have functional implications for durophagy. We therefore quantified bite force over ontogeny in the white spotted ratfish, *Hydrolagus colliei*, using tetanic stimulation of the jaw adductor musculature, and compared these data to theoretical bite force estimates based on a 3D model of jaw and muscle architecture. Bite force increased with positive allometry by virtue of increasing mechanical advantage of the jaw adduction mechanism, and ranged from 12-87 N in 21-44 cm *H. colliei*. Size specific bite force of *H. colliei* is greater than that of non-durophagous chondrichthyan fishes, and is comparable to that of the hard prey eating horn shark *Heterodontus francisci*. As in previous studies the maximal forces predicted from muscle architecture exceeded those achieved by stimulation. Fatigue rate in the bite force of *H. colliei* was compared to that of the spiny dogfish *Squalus acanthias* to identify physiological adaptations in the jaw adductor musculature that allow *H. colliei* to continually graze benthic prey.

AES GRUBER

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Commercial shark industry perspective about large coastal sharks (LCS) of the Atlantic Ocean region.

The Atlantic Shark fishery management plan (FMP) was implemented during April 1993, by the National Marine Fisheries Service (NMFS). The large coastal shark (LCS) management complex was established and consists of twenty-two (22) species of LCS. This shark industry document will be providing illustrations as to the past and current fishing status of these 22 individual LCS species based upon the historical experience of the Atlantic shark fishery participants and known sources of mortality. The past dozen years of federal shark management have benefited all of the LCS species in the US Atlantic Ocean region, as per the opinion of the commercial shark fishing industry. LCS Species Assessment List

The following 22 LCS species are listed in alphabetical order by scientific name: I will however refer to each LCS species by the common name in this document.

Scientific name Common name 1. (*Carcharhinus altimus*) Bignose shark 2. (*Carcharhinus brachyurus*) Narrowtooth shark 3. (*Carcharhinus brevipinna*) Spinner shark 4. (*Carcharhinus falciformis*) Silky shark 5. (*Carcharhinus galapagensis*) Galapagos shark 6. (*Carcharhinus leucas*) Bull shark 7. (*Carcharhinus limbatus*) Blacktip shark 8. (*Carcharhinus obscurus*) Dusky shark 9. (*Carcharhinus perezii*) Caribbean Reef shark 10. (*Carcharhinus plumbeus*) Sandbar shark 11. (*Carcharhinus signatus*) Night shark 12. (*Carcharias taurus*) Sand Tiger shark 13. (*Carcharias noronhai*) Bigeye Sand Tiger shark 14. (*Carcharodon carcharias*) Great White shark 15. (*Cetorhinus maximus*) Basking shark 16. (*Galeocerdo cuvieri*) Tiger shark 17. (*Ginglymostoma cirratum*) Nurse shark 18. (*Negaprion brevirostris*) Lemon shark 19. (*Rhincodon typus*) Whale shark 20. (*Sphyrna lewini*) Scalloped Hammerhead shark 21. (*Sphyrna mokarran*) Great Hammerhead shark 22. (*Sphyrna zygaena*) Smooth Hammerhead shark.

***HUETER, ROBERT; GONZALEZ CANO, JAIME; REMOLINA SUAREZ, FRANCISCO; DE LA PARRA, RAFAEL; TYMINSKI, JOHN; PEREZ RAMIREZ, JUAN**

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Whale shark summer feeding grounds where the Gulf of Mexico meets the Caribbean Sea

In summer months, large aggregations of whale sharks (*Rhincodon typus*) inhabit nearshore waters off Mexico and Cuba in the southeastern Gulf of Mexico and northwestern Caribbean Sea. Biological studies of these sharks to document their distribution, number, size, sex, behavior and migration began off Quintana Roo, Mexico, in August 2003, and are continuing. Research methods include a combination of on-water and aerial surveys, tagging and tracking, and collaborations with local fishermen and guides. The sharks begin to appear in the

area in mid-April and remain more or less continuously through September, apparently feeding on plankton associated with a summer upwelling. A total of 875 on-water sighting records (22 in 2003, 853 in 2004) has been accumulated along with results of three aerial surveys in late June, mid-August and mid-September 2004. To date 191 individual sharks have been tagged (18 in 2003, 173 in 2004). All data indicate that several hundred sharks are present in the area each summer. Estimated sizes of observed sharks range 2-13 m TL; tagged animals range 3.5-12 m TL, with an average size of 6.7 m TL. Sex ratio of tagged sharks is 3.1M:1F. Mature and immature animals are present. Resightings of tagged animals to date have been reported over 300 nm away from the tagging site. Off the northwest coast of Cuba, whale sharks are reported by tuna fishermen and biologists to be present in the fall months. Studies of the sharks in these waters have been initiated to determine their relation to the Mexican shark complex. This area where the Gulf of Mexico meets the Caribbean Sea may comprise one of the most important population centers for whale sharks in the western hemisphere.

HUIZINGA, MERIBETH

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Trophic divergence in sympatric populations of the Gold-breast Splitfin, *Ilyodon furcidens*

The use of the mouth for pacifying and handling prey items has resulted in a variety of resource polymorphisms among vertebrates, altering morphology, life history traits and behavior. Understanding the mechanisms that maintain this type of variation is a central focus in evolutionary ecology. While character displacement, the evolutionary result of interspecific competition for resources, has been used to distinguish ecologically similar species, it is less frequently applied to explain differences in intraspecific morphological variation. Previous studies have demonstrated the presence of coexisting ecological morphs, but few have established a link between this intraspecific morphological variation and fitness. I compared geographically isolated populations of the livebearing Goodeidae, *Ilyodon furcidens*, and described the morphological differences within and between the sample populations. I found that *I. furcidens* exhibits extreme morphological variation in jaw size, and that populations show either a unimodal or bimodal frequency distribution of relative mouth width. Both of these results supported previous work. Morphological variation was then related to fitness estimates and are discussed in the context of maintenance of morphological variation through selection, with implications for disruptive selection. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

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A phyloinformatics infrastructure for morphology

The history of publication of anatomy and morphology is primarily one centered on the talents of skilled artists and illustrators. The illustration of morphological structures demands the ability to convey to the reader of a flat book or journal

features with shape variation in three dimensions. During the last decade, a variety of devices have vastly improved our ability to capture and display images of specimens in digital form. In the 1990s flatbed scanners enabled the digitizing of photographs and hand-drawn illustrations. Today, a \$500, 6-megapixel camera is capable of capturing exquisite detail, even on insect-sized specimens. In addition to these basically 2D proxies for specimens, several emerging technologies are converging to provide unprecedented power for examining, non-destructively and in microscopic detail, the internal 3D structure of highly complex natural specimens. Technologies such as high-resolution X-ray computed tomography (HRXCT) and Magnetic Resonance Microscopy (MRM) produce 3D datasets that yield spectacular visualizations that greatly improve our understanding of the geometry and interior structure of biological features. We are at the threshold of being able to use digital representations of specimens throughout the systematic enterprise. As cost decreases and resolution increases we can expect that these digital datasets will become commonplace. What happens to all of these data? How can we efficiently use these data to document our systematic research? A number of projects have arisen that provide repositories for such datasets: Digimorph, Morphbank, Morphobank, Morphology Net and others. The next step, linking a digital resource to a feature in a description or a node on a cladogram, is an active area of research. The sequence community has a strong history of community infrastructure and is well represented at phyloinformatic efforts like CIPRes. Morphologists will need to step forward to be sure their interests are well represented in these endeavors.

***HUMPHRIES, W. JEFFREY; WALDRON, JAYME L.**

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Thinking outside the rocks: Home range, movement, and arboreal site fidelity of the Green Salamander, *Aneides aeneus*, in the southern Blue Ridge Mountains

It is suggested that plethodontid salamanders, and Green Salamanders in particular, maintain small home ranges. During 2001-2004, in the Blue Ridge Escarpment of South Carolina, we made 496 observations of 147 uniquely marked individual Green Salamanders. Forty individuals were captured > 3 times (26 adults, 8 subadults, 6 juveniles) and used in home range and/or movement analyses. We could not determine home range for juveniles because they tended to move directly to a single tree where they remained for up to several weeks. Home range, maximum inter-capture distance, and maximum distance to rock outcrop were not significantly different between males and females or adults and subadults. However, 3 males had home ranges larger than 250 m² while the largest home range for a female was 118 m². Average home range was 68.2 m² for adults compared to 70.8 m² for subadults; average maximum inter-capture distance was approximately 20 m for both adults and subadults. Average maximum distance to the rock outcrop was 9.5 m and 7.6 m for adults and subadults, respectively, but salamanders were found as far as 33.8 m away from the rock outcrop. Eighty-nine percent of the recaptured salamanders were found in trees or logs at least once during the study, and 7 of 8 individuals found on trees during multiple years returned to the same tree year after year. Salamanders typically migrated away from their overwintering

crevices with the onset of warm weather during spring, and apparently remained in trees or logs for long periods of time, periodically returning to the rock outcrop during the summer. Our study suggests that Green Salamanders have a more complicated life history than previously thought, and illustrates the importance of forested areas around rock outcrops for a large proportion of this species' annual life cycle.

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Spatial relationships in the breeding chorus of the wood frog (*Rana sylvatica*)

The dynamics of breeding aggregations in anurans are complex and the type of breeding strategy often determines the structure of male spacing. For example, in prolonged breeding anurans males are often uniformly spaced because they remain stationary at a call site and often aggressively guard suitable oviposition sites. In contrast, males of explosive breeding species are often randomly spaced and defense is not observed, because they actively search for females and in some cases have communal oviposition sites. With aggregations lasting from a few days to a few weeks, the wood frog (*R. sylvatica*) is an explosive breeding species and exhibits communal nesting. Therefore, in this species we would expect to observe random dispersion of calling males. In the spring of 2004 at Middle Fork Woods Nature Preserve, Kickapoo State Recreation Area, Vermilion County, Illinois, we tested the dispersion of a population of *R. sylvatica* using nearest neighbor analyses. Male dispersion was uniform throughout the pond on the first and final nights of breeding, but was random during intervening periods. Early and late in the breeding period male densities are low thus males were able to maintain some spacing. However, when the density of males increased, dispersion became random and males were often observed calling and moving around the pond.

***HUTCHINSON, DEBORAH A.; SCHROEDER, FRANK C.; SAVITZKY, ALAN H.; MORI, AKIRA; MEINWALD, JERROLD; BURGHARDT, GORDON M.**

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Chemical evidence for sequestration of defensive toxins in the Asian snake *Rhabdophis tigrinus* (Colubridae: Natricinae)

Rhabdophis tigrinus is a bufophagous (toad-eating) snake from Asia that possesses defensive integumentary glands known as nuchal glands. These glands have

been reported to contain bufadienolide steroids similar to those that toads produce from cholesterol precursors. However, nuchal glands lack secretory epithelia and appropriate organelles for toxin synthesis, so it has been hypothesized that *Rhabdophis* does not synthesize bufadienolides, but rather sequesters them from ingested toads. To test this hypothesis, we reared hatchling *Rhabdophis* from four clutches of eggs on controlled diets of fish, nontoad anurans, or toads. Contents of the nuchal glands of dams and hatchlings were collected at various times during the experiment and analyzed with ¹H-NMR. We also analyzed tissue extracts and skin secretions from the prey (*Pimephales promelas*, *Spea multiplicata*, *Scaphiopus holbrookii*, *Bufo terrestris*, *B. quercicus*, and *B. fowleri*). We found that the nuchal glands of unfed hatchling *Rhabdophis* from three clutches lacked bufadienolides and only accumulated the toxins when fed a diet of toads. This is the first chemical evidence of dietary toxin sequestration by *Rhabdophis*. The nuchal glands of all hatchlings from the fourth clutch contained bufadienolides whether the snakes were unfed or had eaten fish, nontoad anurans, or toads. The dam of this clutch, unlike those of the other three clutches, had high concentrations of bufadienolides in her nuchal glands. We suspect that this individual was able to provision her offspring with defensive bufadienolides by transferring the toxins to the yolks of her eggs. Interestingly, hatchlings from this clutch that were fed toads accumulated different types of bufadienolides than those they possessed upon hatching. We plan to test directly the hypothesis that gravid *Rhabdophis* must ingest toads during the period of vitellogenesis in order to provision their offspring with bufadienolides, rendering them chemically defended against their predators. **SSAR SEIBERT ECOLOGY**

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Early development and allometric growth in the armoured catfish *Corydoras aeneus*

Corydoras aeneus larvae were collected at different ages. The development of external morphology and of allometries of several body parts were studied, attempting to reveal important steps in the species' early life history. Based on external morphology, early development of *C. aeneus* was divided into different stages, as described by Balon (1975). After hatching, at a SL of ± 3.5 mm, an eleutherembryonic phase was present, followed by the protopterygiolarval phase (± 4.4 - 5.7 mm SL), the pterygiolarval phase (± 5.7 - 14.0 mm SL) and the juvenile period. In addition, inflexion points were calculated, dividing the growth curve into five different stages of growth speed. Initially, the growth rate (k) was 0.05 until ± 4.0 mm SL, then increasing to 0.19 until ± 5.6 mm SL, and 0.39 until ± 8.0 mm SL. After this, growth rate reached a maximum of 0.67 until ± 16.2 mm SL, slowing down afterwards to a rate of 0.36. Comparison of these data to the allometries of the different body parts lead to the conclusion that the inflexion points found in the *C. aeneus*' early development matched the different key-events known in teleost early development. The transition from endo- to exogenous feeding, when priorities also focus on respiratory functions, was the first point at which allometries changed together with functional demands. A second, similar alignment occurred at the transition to the pterygiolarval phase, with a shift towards locomotory needs. Finally, several inflexions also occurred at the transition to a carangiform swimming mode at 8-9 mm SL.

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Seasonal refuge requirements of the threatened Eastern Indigo Snake (*Drymarchon couperi*) in southeastern Georgia: Preliminary analysis

The Eastern Indigo Snake (*Drymarchon couperi*), the largest North American snake species, was federally listed as threatened in 1978, due primarily to anthropogenic habitat loss and degradation. These pressures remain the greatest threats to the continued survival of this Southeastern Coastal Plain species, with required habitats such as the longleaf pine ecosystem continuing to decline in quality and extent. Throughout its range, *D. couperi* requires sheltered retreats from extreme temperatures, desiccating conditions, and predation. This reliance appears to be more pronounced in the northern portions of the species range (i.e., Southeastern Georgia). The availability of these suitable retreats may have important implications for indigo snake population persistence. We conducted a radiotelemetry study on *D. couperi* from 2002-2004 to investigate the habitat use and spatial ecology of the species in Southeastern Georgia. We tracked 32 indigo snakes during the study at sites on and adjacent to Fort Stewart Military Reservation, Georgia. In addition to the main spatial and habitat objectives of the study, we also examined the type of retreats used. Environmental conditions and shifts in habitat use from cooler to warmer months influenced the type and duration of use of retreats. We recorded most fall and winter locations at gopher tortoise burrows, with reliance on underground refuges less pronounced in the spring and summer as the snakes used more ground debris as cover. The snakes also exhibited shifts in the type of gopher tortoise burrows used. During the cooler months, the snakes were found almost exclusively using active gopher tortoise burrows in xeric pine uplands. Abandoned gopher tortoise burrows were used more frequently in the warmer months, with active burrows used on less than 10% of the recorded locations.

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Early and late migration strategies of juvenile River Herring

Juvenile anadromous river herring (alewives *Alosa pseudoharengus* and blueback herring *Alosa aestivalis*) spend 3-7 months in freshwater before migrating to the ocean, often exhibiting waves of early and late migrators. Migratory patterns and associated biotic factors were examined for both species migrating in 2003 from Herring River in Bourne Massachusetts. Migrating herring were grouped into two temporal periods (early and late for alewives) and separated by species. Differences in body composition (total length, weight, water content, ash content, ash-free dry matter, condition factor), age, growth rate, and hatch date were examined. Migrating bluebacks exhibited a single migratory period (late Sept-October) which occurred between the early and late migratory pulses of the alewives. All migrating bluebacks were of similar size

and weight. Late migrating alewives had significantly greater mean lengths and weights but hatched later than early migrators. Early migrators had greater variation in length (CV = 16% vs 8.5%) and weight (CV= 50.6% vs 27.3%) than late migrators. These patterns may represent distinct migration strategies between early and late migrating alewives and between the two species of river herring. Early migration may be a mechanism by which factors such as competition and low food availability are mitigated. Whereas environmental conditions during the post hatching time of late migrators may allow for a size maximizing strategy promoting migration from the nursery area as late as possible.

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Sequence of fusion in vertebral elements as a possible ontogenetic indicator in crocodylians

The fusion of vertebral elements (e.g., neural arch, centrum, and ribs) are generally thought to indicate relative maturity in various reptilian taxa. However, in recent *Alligator mississippiensis*, *A. siensis*, *Caiman crocodilus*, *Crocodylus actus*, *C. niloticus*, and *C. rhombifer*, complete fusion occurs only between the neural arches and centra or caudal ribs of the several anteriormost caudal vertebrae as well as between the sacral ribs and vertebra in fully-grown individuals. The neurocentral suture of the presacral vertebrae appears to persist throughout the entire life in those Recent crocodylians except a large individual of *C. actus*, which exhibits complete neurocentral fusion in the 12 posteriormost dorsal vertebrae. In the caudal vertebrae of these six Recent crocodylians, complete fusion among vertebral elements takes place cranially from the caudalmost vertebrae, which is common in archosaurs. However, the condition of caudal vertebrae (CD) with a visible suture is variable due to different taxa and/or ontogeny; e.g., from CD1 to 10 in *A. mississippiensis*, CD 1 to 6 in *A. siensis*, CD 1 to 8 in *Caiman crocodilus*, CD 1 to 3 in *Crocodylus actus*, CD 3 to 4 in *C. niloticus*, and CD 1 to 4 in *C. rhombifer*. Thus, the degree of fusion in the anterior caudal vertebrae possibly indicates relative ontogenetic ages in those crocodylian species although minor individual variation does exist. Additionally, complete neurocentral fusion is commonly found in presacral vertebrae of Pleistocene *A. mississippiensis*. The reason for the difference between the fossil and Recent populations of the species is uncertain although it is possible that different rates of fusion can independently result from various biotic (e.g., diet, physiology, and life strategy) and abiotic (e.g., climate) factors.

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The mitochondrial genome of Indonesian coelacanth *Latimeria menadoensis* (Sarcopterygii: Coelacanthiformes) and divergence time estimation between the two coelacanths

We determined the whole mitochondrial genome sequence for Indonesian coelacanth *Latimeria menadoensis*. The genome content and organization were identical to that of typical vertebrates including Comoran coelacanth, *L. chalumnae*. The overall nucleotide differences between the two species (excluding the control region) was 4.28%. The divergence time between the two species was estimated using whole mitochondrial genome data from the two coelacanths and 26 actinopterygians that represent major actinopterygian lineages plus an outgroup. Partitioned Bayesian analyses were conducted with the two data sets that comprised concatenated amino acid sequences from 12 protein-coding genes (excluding ND6 gene) and concatenated nucleotide sequences from 12 protein-coding genes (without 3rd codon positions), 22 transfer RNA genes, and two ribosomal RNA genes. The molecular clock analysis was also conducted with the concatenated amino acid sequences from the 12 protein-coding genes after removing faster or more slowly evolving sequences. Using the sarcopterygian-actinopterygian split as a calibration point (450 Mya), divergence time estimation between *L. menadoensis* and *L. chalumnae* fell in the range of 40–30 Mya, which were much older than those of the previous studies (< 6.3 Mya). Assuming that the most recent ancestor of *Latimeria* was distributed continuously along the deep coasts of Africa through Eurasia, our estimate is in agreement with the hypothesis that the collision of India with Eurasia (50 Mya) and the subsequent siltation caused by the formation of major rivers resulted in a coelacanth habitat disjunction that allowed populations on either side of India to diverge.

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Age, growth and maturity of *Etmopterus baxteri* (Squaliformes: Etmopteridae) from southeastern Australia

In Australia, *Etmopterus baxteri* is one of about 12 deepwater dogfish species that are regularly caught as bycatch/byproduct to demersal trawl fisheries. Recently introduced regulation through a basket-quota management regime (which amalgamates eight commercial deepwater dogfish species) has introduced a TAC of 200 t for 2005. However, high-grading of *E. baxteri* is likely as other species offer more commercial return. The vertebral centra of *E. baxteri* are small and deep-coned. Numerous preparation techniques, including silver nitrate,

ninhydrin and alizarin red, were investigated, although no bands were found. The second dorsal spine of *E. baxteri* is about 50% larger than the first dorsal spine. The relationship between spine length and animal length indicated that the spines continue to grow throughout life, making them a suitable structure for age examination. Bands on the external surface of the second dorsal spine were enhanced with a derivative of alizarin red. Transverse sections at the apex of the pulp cavity yielded bands within the inner dentine layer. The number of bands in each area increased with animal size, although they were dissimilar. The relationship between the two growth zones was compared and we suggest that bands in the inner dentine stop forming and may therefore underestimate age. Length-at-age data from external bands were considered to be more accurate, and were used to estimate longevity, growth and the age at maturity. Male longevity is 48 years with an A50 of 20 years. Female longevity is 57 years. Females matured (A50) at 30 years, although the youngest female with candled uteri was 35 years, and the youngest female with near-term embryos was 39 years. Litter size increases with animal size although the length of gestation is unknown. However, if a 3-year reproductive cycle (from follicle development to parturition) is assumed, the lifetime fecundity for each female is about 81. Male and female growth was similar until the onset of male maturity. The VBGM for each sex is as follows: Male: $64.57(1-e^{-0.065(t+4.36)})$ $r^2 = 0.82$; $n = 83$ Female: $83.6(1-e^{-0.038(t+4.98)})$ $r^2 = 0.80$; $n = 158$.

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Having an open mind: The unique anatomy of the Rockhead Poacher

The Agonids (Poachers) are a family of bottom dwelling fish common in the sub-arctic waters of the Northern Pacific. Their bodies are covered in dermal plates and they have a post-cranial pit that is developed to varying degrees. The Agonids make a low pitched humming sound, but the method of sound production has not yet been determined. Our research investigates the unusual anatomy of the post-cranial pit and whether or not the post-cranial pit is related to sound production and/or sound reception. A high resolution CT scan of *Bothragonus swani* (Rockhead Poacher) was used for anatomical study. Using a 3-D imaging program we observed the depth and diameter of the cranial cavity and the distinct morphology of the skeleton of the anterior half of *B. swani*. The anterior ribs have been modified to closely follow the contours of the calcified pit and may be the source of the humming sounds via stridulation. Bones in very close proximity to the calcified pit are also present and appear to be closely associated with a series of skull bones that lead to projections that cradle the otoliths.

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Tempo and mode of diversification of endemic New Caledonian lizards

The New Caledonian herpetofauna consists almost entirely of geckos and skinks. Molecular phylogenetic analyses show that although the two groups of lizards show very different patterns of diversification, the common ancestor of both groups within New Caledonia is roughly the same time, late Oligocene/Early Miocene. The common time to common ancestry may be the result of a concurrent sea level rise at that time. Both groups of lizards show an early rapid burst of speciation with many more lineages involved early on in the evolution of New Caledonian skinks compared to geckos. In both cases, however, the rate of diversification is relatively constant. Although both groups include examples of adaptive evolution, most of the diversification of lineages appears to be non-adaptive with many ecologically similar forms speciating as the result of isolation.

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Seasonal activity and movement patterns of the Black Pine Snake
(*Pituophis melanoleucus lodingi*) in southern Mississippi

The Black Pine Snake (*Pituophis melanoleucus lodingi*) is considered a state endangered species in Mississippi, and is a Federal candidate for listing by the United States Fish and Wildlife Service. Because of the species rarity and somewhat secretive behavior, knowledge of *P. melanoleucus lodingi* seasonal activity and movement patterns is lacking. The capture dates of historical museum specimens (dating back to 1915) and more recent field captures (over the past year) were used to determine peaks in pine snake seasonal activity. These data suggest that males are more active than females during March, April, May and July (presumably as a result of mate searching) and females are more active than males during June (presumably as a result of nest site selection). These findings were further reinforced when the monthly movement patterns of six telemetered pine snakes (4 F: 2 M) from an ongoing investigation were examined. An analysis of the telemetered pine snakes movement patterns suggests that males have a considerably larger home range than females. These data should be useful in developing a monitoring protocol for this rare species in Mississippi.

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Numerical discrimination by red-backed salamanders

When encountering prey, red-backed salamanders (*Plethodon cinereus*) are able to discriminate 0 vs. 1, 1 vs. 2, 2 vs. 3 prey, but do not discriminate 3 vs. 4, or 4 vs. 6

prey. Thus, their ability to discriminate prey numbers appears to be 1, 2, 3, more than 3. Three hypotheses may explain this discrimination: a mental concept of number, attraction to more mass of flies (3 flies have more mass than 2 flies), or attraction to more movement of flies (3 move more than 2). Recent results do not support the "more mass" hypothesis but do suggest that spatial distribution of prey (distance between prey and overall horizontal spread of prey) influences their ability to discriminate numerically.

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Changes in the digestive tract of American eels during the yellow to silver phase metamorphosis.

We examined histological and apoptotic changes in the digestive tract of yellow and silver phase American eels at different stages of the yellow-silver metamorphosis. It is thought that upon migration, a silver eel stops feeding and reabsorbs its digestive system. Eels forced to delay their migration would be unable to maintain energy reserves necessary to complete the spawning migration at a later date. Migrating silver eels were collected and held in the laboratory for 10 months, divided into fed and non-fed groups, and individuals sacrificed at one month intervals to examine changes in their digestive tracts. Preliminary data indicate that, similar to previous studies, the overall digestive tract size was reduced as the silver metamorphosis progressed, but as of yet no complete loss of digestive tract has been observed. The cause of the degeneration of digestive tissues appears to be the result of programmed cell death and not necrosis or atrophy. In addition, Silver eels presented food maintained feeding throughout the experiment. This is being further explored by artificial maturation and over wintering experiments currently underway as well as a examination of changes in muscle, epithelial layer, and levels of apoptosis in both tissue types.

JANOVETZ, JEFF

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The kinematics of biting prey capture in pacus, silver dollars, and piranhas

Despite being the characteristic method of feeding for a number of species-rich and ecologically important groups, the kinematics of biting prey capture have rarely been investigated in fishes. This study compares both biting and suction prey capture in three species of characin fishes from the subfamily serrasalminae; *Piaractus brachypomus*, a pacu, *Metynniss argenteus*, a silver dollar, and *Pygocentrus nattereri*, a piranha. These closely related species differ dramatically in their natural diets, but all depend primarily on biting with the oral jaws to capture and process prey. All three species retain the ancestral ability to suction feed. The sequence and extent of cranial movements during suction feeding are within the range of values reported for other fishes during this behavior, although the time required for these movements is considerably longer in serrasalmines. Biting is a

statistically distinct behavior from suction feeding in most measures of cranial movement and in the timing of these movements. Biting pieces from squid is characterized by a relatively large degree of cranial expansion in both *Piaractus* and *Pygocentrus*. Herbivorous bites on leaves in *Piaractus* and *Metynnis*, and squid biting in *Metynnis*, are characterized by relatively low displacement of cranial elements. Despite these differences in displacement, the timing of these movements is similar during both carnivorous and herbivorous bites. Biting is modulated according to differences in prey and is a highly variable form of prey capture in serrasalmines, with statistically significant differences in feeding kinematics between species feeding on the same prey, and within a species when feeding on different prey.

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ADRIAENS, DOMINIQUE**

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Phylogenetic, biogeographic and divergence time analysis of anguilliform air-breathing catfish (Siluriformes: Clariidae) inferred from ribosomal gene and spacer sequences

The catfish family Clariidae comprises species in which the body shape ranges from fusiform to anguilliform. Recent studies have shown that the evolution involving body elongation is the result of convergent evolution. This study tries to find an answer to remaining questions regarding the evolution towards anguilliformity, as well as its paleobiogeographical background. Sequences of 29 taxa were analyzed using the neighbor-joining, maximum-likelihood, maximum-parsimony, and Bayesian inference algorithms and the parsimony algorithm in POY. The study yields phylogenetic hypotheses showing well-supported clades. Phylogenetic dating was performed with semiparametric rate smoothing by penalized likelihood, using two reference fossils for calibration. Divergence time based on the ribosomal ITS1-5.8S-ITS1 region and fossil constraints indicate that the African Clariidae started radiating between 123 and 56 My ago. *Heterobranchus isopterus* (a close relative to Clariidae) is older (about 123 My) and may be a survivor of old clades that went extinct at the K/T boundary. The extant Clariidae originated in the Miocene. Anguilliformity could have evolved in different lowland forest refugia in Central West Africa, where a selective pressure could have favored the rise of eel-like burrowers, better adapted to living in rain forest flood plains and swamps. After subsequent expansions of the forest patches, the fusiform taxa could have spread again using their adaptations to survive in large rivers and to cross land bridges between them, whereas the specialized anguilliform taxa would have been more restricted to their moist habitats.

JAVONILLO, ROBERT

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Histological characters in the systematics of glandulo-caudine fishes (Teleostei: Characidae)

Glandulo-caudinae is a subfamily of freshwater Neotropical fishes of the family Characidae. The name is based on the presence of putative glandular cells in association with hypertrophied scales on the caudal peduncle and fin of males. The histology of these cells was previously studied in only a single species, *Corynopoma riisei*. The glandular cells of *C. riisei* appeared to be hypertrophied mucous cells, given their positive staining with the periodic acid-Schiff reaction. I have been analyzing the caudal glands of species from most of the genera of Glandulo-caudinae using the glycol methacrylate histological technique. Preliminary results indicate that some, but not all, glandulo-caudine adult males have hypertrophied mucous cells in the caudal region. *Hysteronotus* and *Pseudocorynopoma*, for example, exhibit greatly hypertrophied mucous cells lining the pockets formed by hypertrophied scales. This pocket is lined with mucous cells of typical size, but differing densities in *Scopaeocharax* and *Xenobrycon*. Species belonging to the tribe Glandulo-caudini have cells near the caudal peduncle that resemble the alarm substance cells known to be present in ostariophysan fishes. In a more posterior area, male *Acrobrycon* (tribe Diapomini) exhibit pits that open to the external environment and that are lined with unmodified mucous cells. These results, coupled with other morphological data from these fishes, have led to a re-analysis of the relationships among the glandulo-caudines. A new phylogenetic hypothesis recommends separating Glandulo-caudinae *sensu lato* into two subfamilies: Glandulo-caudinae *sensu stricto* and Corynopominae.

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Removal sampling of an endangered darter: Advantages for estimating populations

Most abundance information on endangered fishes is based on counts of organisms from a wide variety of techniques. Despite the method or quantitative rigor employed, these counts underestimate population densities and need to be adjusted for imperfect detection. While monitoring the Okaloosa Darter (*Etheostoma okaloosae*) at Eglin Air Force Base in northwest Florida, we sought to validate our visual survey method. Three removal passes over 20-meter reaches of stream allowed us to simultaneously estimate the abundance and detection of darters at 28 sites. Hierarchical spatial models using negative-binomial distributions of abundance and Beta distributions of detection provided better estimates of both parameters than traditional Zippin estimates at each individual site. Average detection was 0.6 for individual removal passes. Extrapolating our abundance estimates across drainages gave surprisingly high estimates of total population. Because seining is the most common method used to estimate darter

abundance, we explore the number of sites and removals necessary to get similar results.

JENKINS, CHRISTOPHER L.

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Linking landscape disturbance to population level variation in western rattlesnake life histories

The synergistic effects of livestock grazing, invasive plants, and fires are altering the sagebrush steppe ecosystems of southern Idaho. This phenomenon is having a negative impact on a number of wildlife species that inhabit these systems. Our preliminary results from a 14-year mark recapture data set of two western rattlesnake populations shows that there is significant geographic variation in life histories among populations. In addition, we found that a reduction in prey base due to disturbance alters snake life histories. The goal of this study is to determine if difference in the level of disturbance between two rattlesnake populations (one with low life history values and one with high life history values) cause differences in the prey bases resulting in the observed life history differences. We used radio telemetry to follow 30 snakes during the 2003-2004 active seasons and measured a suite of habitat characteristics and trapped small mammals at each snake location and a series of random locations. We found that small mammal biomass is associated with habitat characteristics typical of undisturbed sagebrush steppe including a positive relationship with shrub height and biological crust cover and a negative relationship with grass cover. We also found that snakes were captured in areas with higher small mammal biomass relative to random locations. In addition, habitats were more disturbed and small mammal biomass was lower in the areas inhabited by the rattlesnake population with low life history values. Our results suggest that widespread disturbance is having a negative impact on rattlesnake life histories through a series of trophic interactions. Suggestions for conserving remaining undisturbed areas and restoring disturbed areas are discussed. **STOYE CONSERVATION**

***JIMENEZ, CYNTHIA G.; BURBRINK, FRANK T.; LAWSON, ROBIN**
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Genetic variation in northeastern United States populations of *Thamnophis sirtalis*

Current studies on the common garter snake (*Thamnophis sirtalis*) suggest that this species may be composed of multiple independently evolving lineages (Lawson *et al.* in prep). In the Northeastern United States two distinct clades have been identified. Due to lack of samples it is unclear if these clades are confined to specific geographic areas. Moreover, it is unknown if a geographic or environmental barrier has caused this division or if this barrier restricts gene flow. This project will attempt to locate and determine the nature of the genetic

break among *T. sirtalis* in the Northeastern United States. We are currently sampling throughout this area, concentrating on areas where the clades come into close proximity to each other. Using the maternally inherited mitochondrial gene, cytochrome-*b*, we are classifying individuals into either clade in order to isolate the potential geographical position of the break. We are also looking at single-copy nuclear genes (alpha-Enolase and *c-mos*) in order to determine if the break is supported by nuclear evidence. If both types of DNA show support for this division it may indicate past or present reproductive isolation.

JOHNSON, G. DAVID

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Ontogeny and phylogenetic systematics: An old frontier, waiting

Publication of the proceedings of the Ahlstrom Memorial Symposium, *Ontogeny and Systematics of Fishes*, in 1984, heralded a new era for the incorporation of developmental stages into mainstream systematic ichthyology. More than twenty years later, it seems that the predicted revolution never came to pass. Most comparative anatomical and phylogenetic investigations during the ensuing period have failed to take advantage of the rich and critical source of character information that larval stages can provide. The well-documented differences between larvae and adults of marine fishes in pigmentation, shape, and especially ornamentation are all too frequently ignored in phylogenetic analyses. Likewise, and most importantly, with all fishes, the enormous potential for solving long-standing questions of homology remains largely untapped. The reasons for this lapsus are clear enough. Most ichthyologists are not trained in, or even exposed to, the handling, identification, and study of tiny fish larvae. Furthermore, the work is highly labor intensive and requires singular dedication to obtaining and preparing the appropriate material. For freshwater fishes, the solution may be found in rearing. For marine fishes, with some exceptions, collections must be scoured not only to locate developmental series, but also to identify those that will clear and stain properly. Nevertheless, without these efforts we turn our backs on a critical piece of the puzzle. With the rising dominance of molecular systematics, morphology is often viewed by academic institutions and funding agencies as an old-fashioned science, much of the important work having now been completed. This is absurd, for molecular systematists and evolutionary developmental biologists have no engaging questions to ask without a deep understanding of morphology, and without ontogeny that deep understanding is unreachable. Can morphology-based systematic ichthyologists afford to ignore the most morphologically dynamic part of the life history of their organisms? Maybe not. By embracing the study of development, we can so clearly demonstrate the value of our work and how much remains to be done, as I hope to demonstrate with selected examples from recent work. Comparative morphology is founded in exploration and discovery - an old frontier awaits.

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A remarkable rib/swimbladder association in the moonfish, *Mene maculata* (Perciformes: Menidae)

The moonfish, *Mene maculata* (Perciformes: Menidae), is distributed in deeper coastal waters of the tropical Indo-Pacific. Distinctive features include a highly compressed, disc-like body, highly protrusible upper jaws, elongate second pelvic ray, and extremely truncated, embedded anal soft rays. The osteology of *Mene* is known almost exclusively from descriptions of fossils, particularly those from the Eocene deposits of Monte Bolca, Italy. These fossils are primarily two dimensional, and details of the posterior portion of the braincase and anterior portions of the axial skeleton below the midline are almost always obscured by the opercle and pectoral girdle. As a consequence, remarkable modifications of the anterior vertebrae and first two ribs of this relatively common Indo-Pacific fish have gone unrecognized since its original description over 200 years ago. Most striking of these are the hypertrophied first ribs, which have medial and lateral expansions embracing paired, thin-walled anterior ducts of the swimbladder that attach to the first centrum and basioccipital. The large first ribs are braced by expansions of the second ribs and strut-like, anteriorly inclined parapophyses of the fifth vertebra. The moveable first vertebra has an autogenous neural spine and paired transverse processes giving rise to stout ligaments that expand to cover the lateral walls of the swimbladder ducts and insert on the first ribs. We illustrate these skeletal modifications with wet and dry skeletal preparations and high-resolution X-ray computed tomography. We are still in the process of investigating the soft tissue aspects of this complex, and can only speculate at this time that its function is related to sound reception and/or production.

JOHNSON, JARRETT R.

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Terrestrial habitat distribution of the treefrog, *Hyla versicolor*: Evidence from experimental arboreal refugia and radiotelemetry

Fragmentation of the terrestrial landscape has exacerbated the need to understand the core habitat requirements of highly mobile organisms, or those that undergo seasonal migrations, such as pond breeding amphibians. Current research indicates that most pond-breeding amphibians spend much of their lives in terrestrial habitat at some distance from the aquatic sites on which they depend for reproduction. The core habitat for a particular individual would encompass the specific terrestrial habitat area adjacent to a breeding site that is used for activities such as foraging or overwintering, plus the expanse of habitat through which it moved to reach the area. From a population-level perspective, the core habitat encompasses all of the core habitats of the individuals that breed at a particular site. Movements and activities that occur away from aquatic breeding habitat are important aspects of pond-breeding amphibian species life histories, but are notoriously difficult to study in many cases. To elucidate core

habitat requirements, gray treefrog movements through terrestrial habitat adjacent to breeding ponds were monitored using mark-recapture techniques and experimental arboreal refugia. Additionally, a subset of individuals captured in pipe refugia were implanted with radiotransmitters and tracked for approximately one month following the breeding season. Most radiotracked individuals were ultimately located in overwintering sites at or below ground level following periods of nearby arboreal refugia use. Our results indicate that gray treefrogs undergo yearly migrations between foraging grounds, overwintering sites, and breeding ponds of 200 m or more. Furthermore, females travel further than males, placing them at the periphery of the core habitat of the population. The data suggest that habitat destruction resulting in small (<200 m radius) fragments of forested habitat surrounding breeding sites may have a greater negative impact on females than males, and ultimately cause a reduction in local population sizes. **STORER HERPETOLOGY**

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The effects of inter-pond distance and matrix habitat on treefrog movements in a fragmented landscape

The destruction of natural habitat has created a landscape of small, separated patches of habitat for many species. The need to understand the effects of habitat fragmentation and preserve naturally functioning populations within remaining habitat patches has led to an increase in the use of metapopulation theory in conservation biology. An understanding of the effects of distance and habitat matrix are crucial to implementing conservation programs aimed at the scale of protecting metapopulation dynamics. Pond-breeding amphibians represent an appropriate group in which to study metapopulations because the local habitat patch is centered on a breeding pond (or ponds) that often can be identified and measured. Many pond-breeding amphibian species are forest-associated, and habitat destruction may inhibit dispersal among local populations and lead to increased risk of local extinctions. To determine how amphibian dispersal between breeding sites is limited by distance and matrix habitat, movement rates of the gray treefrog (*Hyla versicolor*) were monitored among breeding sites separated by varying distances, and across alternative habitat types, in experimental metapopulations comprised of cattle tanks. Inter-pond movements were recorded using a combination of mark-recapture techniques and DNA fingerprinting using microsatellite markers. Movements through old-field matrix were significantly less frequent than those through oak/hickory forest for both adults and juveniles, and the distance between ponds significantly influenced the frequency of adult movements within and among consecutive breeding seasons. These results indicate that gray treefrogs are capable of moving large distances through terrestrial habitat, but that forested habitat poses less resistance to movements than old-field habitat. Furthermore, habitat composition and inter-pond distance appear to have varying influences on movements depending on life history stage. The data suggest that interruption of continuous forested habitat will decrease the frequency of dispersal among local populations of forest-associated amphibians and could subsequently alter extinction/recolonization rates within pond-breeding amphibian metapopulations. **SSAR SEIBERT ECOLOGY**

***JOHNSON, K.K.; LOWE, C.G.**

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Bioenergetics of kelp bass, *Paralabrax clathratus*

As top-level predators, kelp bass (*Paralabrax clathratus*) feed on a variety of organisms such as squid, octopi, crabs, shrimps and other fishes, and thus are important in shaping prey populations within the kelp bed community. Metabolism was measured for kelp bass of varying sizes in a static respirometer over periods ranging from 2-24 hrs. Mass specific metabolic rates were determined for 18 fish ranging from 0.51 g to 970 g at $18\pm 1^\circ\text{C}$ in order to quantify minimum energy requirements of individuals in the field. The average standard metabolic rate (SMR) for kelp bass recruits (0.71 ± 0.18 g) was 0.26 ± 0.09 mg O₂h⁻¹, while the average SMR for the juveniles and adults (379 ± 277 g) was 19.2 ± 12.3 mg O₂h⁻¹. No routine metabolic rate (RMR) was observed for kelp bass recruits; however, juveniles and adults had an average RMR of 25.5 ± 15.6 mg O₂h⁻¹. There was no significant difference in average SMR of fish between day and nighttime periods. Metabolic rates of kelp bass were used to develop an energy budget for two populations of fish located inside and outside a marine reserve based on size-abundance estimates. Although both populations possessed the same numbers of fish, the population within the reserve had significantly larger kelp bass. Using the mass specific standard metabolic relationship derived for kelp bass, the population with larger fish burned, at minimum, 73% more energy than the population of smaller fish.

***JOHNSON, VALERIE M.; GUYER, CRAIG**

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Seasonal and diel mating activity of Gopher Tortoises

Although courtship behavior for Gopher Tortoises is well understood, seasonality of mating activity is based on sporadic observations of relatively few individuals. Using remote cameras to monitor 53 selected females at four sites, we documented seasonal variation in Gopher Tortoise mating behavior. Gopher Tortoise mating behavior peaked during July, August, and September, a pattern that mimics hormone cycles. During peak months of mating, the majority of mounts occurred during midday and late hours. The average minimum number of males that mounted a female during a season of activity was three.

***JONES, L.M.; DRYMON M.; JOHNSON K.A.**

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Age and growth of the smooth dogfish and the Florida smoothhound in the U.S. Gulf of Mexico.

The smooth dogfish and the Florida smoothhound are common in the U.S. Gulf of Mexico. Here we report on the preliminary results of an investigation into the life history of both species. Specimens were collected during all months of the

year from southwest Florida to Texas by commercial fishermen and during National Marine Fisheries Service trawl and longline surveys. Ages were obtained by analyzing growth bands on vertebral centra. Age estimates were used to generate sex-specific von Bertalanffy growth models for each species. The annual deposition of growth bands was validated up to an age of 8 for females of and 6 for males of . The periodicity of growth band deposition was verified using marginal increment analysis. Reported results also include size at parturition and size and age at maturity.

JORDAN, LAURA K.

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How are habitat and prey preference of batoid fishes reflected in sensory anatomy and prey capture?

Feeding behavior in elasmobranch fishes has frequently been studied in sharks rather than their batoid relatives. The present study is focused on the feeding behavior of three species of rays. Rays are ancestrally benthic fishes though some groups have evolved a pelagic lifestyle and have separated themselves either partially or completely from the benthos. The transition to pelagic life coincided with a transition from undulatory to oscillatory modes of locomotion with modified body designs in some species, as well as a shift in diet. Species which remain intermediate to the benthic and pelagic habitats, termed benthopelagic, are powerful swimmers and can swim large distances over deep water but remain tied to the benthos for feeding. A benthic, *Urobatis halleri*, a benthopelagic, *Myliobatis californica*, and a pelagic ray, *Dasyatis violacea*, are compared to investigate differences in anatomy and prey capture behavior. Typical prey and preferred prey are also compared between ray species to see if prey characteristics and habitat are reflected in prey detection and capture. The electrosensory and mechanosensory systems are compared between the three species through mapping and quantification of electroreceptor and lateral line pore and canal distributions. Analysis of body and jaw movements are included to characterize and compare prey capture strategies as they relate to habitat and preferred prey. Future studies will identify behavioral responses as indicators of detection thresholds of the lateral line and electroreceptor systems. Underwater video of feeding in the field will also be used to supplement lab studies of feeding behavior. **AES CARRIER**

***JORDAN, REBECCA; HOWE, DAVID;**

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Latent female preference for dorsal fin characteristics in mollies

Sexual selection through female choice may influence speciation in some systems. The mollies (Pisces: Poeciliidae), a diverse group of neotropical freshwater fishes, provide an opportunity to investigate female choice across a variety of mating systems. In this study, we investigate the potential for female preference in a species where female preference appears absent in the wild. Such

latent preferences can then be compared across species and among populations to investigate trait evolution and subsequent species diversification. *Poecilia gilli* were collected from two Panamanian streams that differ markedly in habitat conditions. We conducted three experiments to test female preference for males, female preference for females, and male preference for females. In each experiment, subject fish were given the choice of fish from their native stream and the foreign stream. We found that females preferentially associated with local males but preferred neither local nor foreign females. Males exhibited no preference for females based on stream of origin. In addition, we found that males differed in dorsal fin height between groups. The results provide evidence for latent female choice and the evolutionary consequence of this phenomenon is discussed with particular regard to recently collected data on a closely related species *P. mexicana*.

JORGENSEN, MICHAEL E.

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**Growth patterns in the embryonic cranium of the Red-eared Slider
(*Trachemys scripta*)**

Developmental events, growth patterns, and shape change in the amniote skeleton have been described in birds, crocodylians, lizards, and mammals. However, little focus has been placed upon the skeletal ontogeny of turtles, and even less on the ontogenetic change in shape of the skull and chondrocranium during early development. Geometric morphometric methods can be used to describe shape change of complex skeletal structures such as the skull through ontogeny, allowing one to examine intra- and interspecific differences among taxonomic groups. Covariation of growth patterns with factors such as size, geography, and temperature then can be examined with multivariate statistics. Herein, ontogenetic shape change is described for the embryonic skull and chondrocranium of *Trachemys scripta*, the Red-eared Slider, using tpsRelw version 1.41. I assessed allometric growth patterns of various regions of the skull (nasal capsules, otic capsules, orbital region, occipital region, braincase, and quadrate) in 25 cleared and double-stained embryos (Stages 19–25) of *T. scripta* that were incubated in the laboratory under constant temperatures. Results are described and visualized using thin-plate spline deformation grids, which allow for a discussion of relative shape changes in various regions of the skull.

STORER HERPETOLOGY

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Genetic relatedness among several populations of the Northern Dusky Salamander (*Desmognathus fuscus*)

It is thought that geographic separation can lead to genetic isolation, a process often illustrated by island populations. Within apparently contiguous populations, however, sufficient distance should reduce gene flow. Northern dusky salamanders (*Desmognathus fuscus*) are small ectothermic vertebrates, and

reasonably restricted to stream-side habitats by their need for moisture. Thus, they are of relatively low vagility, which ought to restrict gene flow, compared to larger, more vagile organisms. Therefore, we hypothesized that genetic variation should be detectable among populations of dusky salamanders separated by modest distances. To test this hypothesis, we collected *D. fuscus* tail tips from four locations ranging from central Ohio to eastern Kentucky. After phenol-chloroform-isoamyl extraction, we subjected the extracted DNA to polymerase chain reaction, gel electrophoresis, Southern blotting, and rehybridization with fluorescing single stranded DNA markers. Analysis included visualization of fluorescing components of the rehybridized DNA, and matching of fragments of similar length, followed by statistical analysis of the data. Fragment length matching formed the basis of the statistical analysis, which included comparing the amount of genetic relatedness (determined from the number of matching DNA bands) between and within locations. As expected, some statistical differences were found, but, since the separation distance of these samples was not large compared to the geographic distribution of the species, the degree of genetic isolation was not large. The pattern of DNA variation was not always the same for the two sexes.

***KAGIMA, BARBARA; VALENZUELA, NICOLE**

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Maternal effect genes for sex determination in painted turtles, *Chrysemys picta*

Maternal effects can have important consequences for sex ratio evolution in species with temperature-dependent sex determination. Documented maternal effects in TSD reptiles include nest-site choice and allocation of nutrients and steroids to egg yolk. We examined the presence of maternal effect genes in the yolk of *Chrysemys picta*, a TSD turtle. Our results include the detection and profiling of mRNA in the yolk of developing embryos. We discuss the implications of these results for the evolution of temperature-dependent sex determination in reptiles.

KAHN, PAULA F.

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Moving Jitters: The relationship between relocation and stress in gopher tortoises (*Gopherus polyphemus*)

Declines in gopher tortoise (*Gopherus polyphemus*) populations have been attributed to extensive habitat loss in the southeastern United States. Currently, relocation is the method used most frequently to protect these animals. However, studies have not yet been conducted to determine how gopher tortoises respond to relocation physiologically. If relocation is a stressful event for tortoises, then they may experience high levels of corticosterone (the hormone associated with the stress response) that may lead to impaired post-relocation health and reproductive abilities. Furthermore, high corticosterone can be particularly detrimental to gopher tortoises as it could increase their vulnerability to Upper

Respiratory Tract Disease (URTD), a bacterial disease particular to tortoises. As a result, relocation, the very tool we use to try to protect the tortoises, may cause changes in stress that could lead to compromised health and recruitment for this threatened species. We conducted a study at Ft. Benning in Georgia during 2003 and 2004 to determine the physiological effects of relocation on gopher tortoises. Just before and 30 days after relocation, we took blood samples to measure baseline corticosterone. We also measured tortoises' adrenal responsiveness by injecting them with a natural substance, ACTH (adrenocorticotrophic hormone). Normal, healthy tortoises respond to the injection with a peak in corticosterone 4 hours post-injection. If no peak occurs, the tortoise may be experiencing high stress levels that prevent further response to acute stressors. These measures will be correlated with immune responses and reproductive profiles to determine the potential effects of relocation on URTD and recruitment. **STOYE PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY**

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Summer patterns of microhabitat use by blackbanded darters in northwest Florida

Blackbanded darters (*Percina nigrofasciata*) are small benthic fish found in streams of the Gulf and southern Atlantic Coastal Plains. We quantified abundance of blackbanded darters and examined their patterns of microhabitat use during the summer of 2002. Fish were counted in 20-m stream sections while snorkeling and their positions were marked with size-coded survey flags. We then determined the substrate type, bottom flow, midwater flow, canopy cover, distance to bank, distance to open sand, and depth for each fish. Blackbanded darters preferred streams that were deep, fast, wide, and covered by a well-developed canopy. Fish were typically found on or near patches of sand. Patterns of microhabitat use varied among size classes and may reflect differences in vulnerability to predators. Larger fish occupied deeper and faster flowing water than small fish. Similarly, larger fish were more likely to occupy open sand and stray further away from abundant cover along stream margins.

KAISER, KRISTINE

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Evaluation of the Maya Forest Amphibian Monitoring Project protocol in Central America

Amphibians in the tropics historically have been studied less than their temperate counterparts; there are very few long-term monitoring efforts in place in these regions, despite the recognition that amphibian declines have been greatest in tropical montane regions. In 1997, the Declining Amphibian Populations Task Force established the Maya Forest Amphibian Monitoring Project (MAYAMON) to initiate long-term monitoring of amphibian populations in Belize, Guatemala, and Mexico. From May through August 2002, I carried out

a field study of the efficacy of the MAYAMON sampling protocol at Las Cuevas Research Station in Belize. I conducted 119 calling surveys for vocalizing anurans at 4 ponds. I assess how the length of surveys, number of surveys per month and monitoring site selection affect accuracy and precision of the data collected by the MAYAMON protocol. Fifteen- and thirty-minute sampling periods were significantly different, but regression suggests that the optimal sampling time falls somewhere between the two periods: in my surveys, the protocol reached 90% detection efficiency at 21 minutes. One survey per month is not likely to detect all species present; in particular, explosive breeders may be missed. Added surveys at the onset of the rainy season when most species are reproductively active could make detection of explosively breeding species more likely. The species assemblage varied among the four survey ponds, suggesting that site selection is important in accurately assessing populations and assemblages. A volunteer protocol must remain easy to carry out, and while there are minor improvements that could be made to the MAYAMON protocol to improve its detection efficiency, I conclude that the MAYAMON protocol is a good model for similar efforts in tropical zones.

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Olfaction in sphyrnid sharks

Hammerhead sharks (Family Sphyrnidae) are characterized by a unique head morphology in which the olfactory capsules of the cartilaginous neurocranium are laterally expanded. The enlarged olfactory capsules contain correspondingly large olfactory organs. It has been hypothesized that the widely spaced incurrent nares and large olfactory organs of sphyrnid sharks might confer directional localization of odors and enhanced olfactory sensitivity compared to their carcharhinid relatives. We tested these hypotheses by comparing the morphology of the peripheral olfactory system in all eight extant sphyrnid species as well as two carcharhinid species. The distinct prenarial grooves, characteristic of most sphyrnid species, channel water from along the anterior margin of the cephalofoil laterally into the incurrent nares. This effectively reduces the separation distance between left and right nares to a distance comparable to that of carcharhinid sharks. In addition, although sphyrnid sharks typically possess a greater number of olfactory lamellae than carcharhinid sharks, the dorso-ventrally compressed cephalofoil constrains the proportions of the lamellae such that the total lamellar surface area does not differ between comparably sized scalloped hammerhead sharks, *Sphyrna lewini*, and sandbar sharks, *Carcharhinus plumbeus*. An electro-olfactogram technique was employed to quantify the response of juvenile scalloped hammerhead sharks to a variety of proteinogenic amino acids. The amino acids differed significantly in their ability to elicit responses from the olfactory epithelium of the sharks. Aspartic acid and proline yielded the lowest magnitude responses in the scalloped hammerhead with minimum detectable concentrations around 10^{-5} molar. Cysteine and serine yielded the greatest response magnitudes with minimum detectable concentrations less than 10^{-7} to 10^{-8} molar. These values are comparable with

values for other elasmobranch fishes and, taken in conjunction with the morphological data, seem to indicate that sphyrid sharks might not possess any extraordinary olfactory capabilities.

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Population patterns of a riparian frog (*Rana swinhoana*) before and after an earthquake in subtropical Taiwan

We compared the population dynamics of *Rana swinhoana*, before and after a strong earthquake (7.3 on the Richter scale on September 21, 1999) from August 1996 to September 2001. We recorded all frogs observed from a 300 m stream transect and 30 m transect beside four ponds (numbered 1-4). The earthquake caused little disturbance to the vegetation and landscape of the study site. However, within a week after the earthquake, the stream and ponds 1, 2, and 4 had completely dried up, and pond 3 was reduced to a shallow pool of water. Nearly all frogs marked (1002 out of 1004 frogs) before the earthquake disappeared after the earthquake. Smaller, unmarked frogs began to appear in stream habitats about nine months after the earthquake, and the frog population was much smaller than it was before the earthquake. Population dynamics and temporal and spatial distribution of frogs, before and after the earthquake, correlated closely with the hydrology of the stream and ponds. The movement patterns of frogs before and after the earthquake were similar, suggesting frog behavior did not change in response to drastic changes in habitat hydrology, and frogs continued to exhibit strong site-fidelity. After the earthquake, stream water volume was much lower, especially in the summer, which allowed the normally winter-breeding frogs to breed year round. Our results demonstrate that a population of *R. swinhoana* can disappear suddenly as the result of a natural disturbance. Available evidence suggests that the changes in stream and pond hydrology, caused by the earthquake and subsequent dry season, were responsible for the population fluctuation. We propose that anuran species that exhibit strong site-fidelity are particularly susceptible to extirpation of local populations because adult frogs may lack the behavioral plasticity to respond to a sudden depletion of water.

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The ecology of bullsnakes in upper midwestern prairies

Bullsnakes (*Pituophis catenifer sayi*) are the largest snakes native to the Upper Midwest. Despite having a close association with oak savannahs/sand prairies and experiencing significant population declines within the past several decades, little research has been conducted on these snakes in the Upper Midwest. Objectives of this study include determining: 1) general habitat preferences for

thermoregulation, hibernation, nesting, and foraging, and 2) home range size and movement rate, 3) the effects of agriculture and prairie management techniques (i.e. controlled burning) on home range sizes and habitat preferences. Radio telemetry equipment was used to track 20 snakes (11 males, 9 females) during periods of activity in 2003/04 (and is currently ongoing). Upon location with telemetry equipment (at least weekly) location data, and several structural habitat and environmental parameters were recorded. Because controlled burns, invasive vegetation species removal and pesticide application are often incorporated during prairie restoration/management, it will be useful to know the response of bullsnakes to such activities. Currently, both of the study sites are part of a habitat management plan that includes scheduled spring burning of specified areas, and snake responses to this management is being documented. While no difference was found in the Overall Movement Rates (OMR) of male and female snakes in 2003, a significant difference in the size (Ha) of Minimum Convex Polygon home ranges between male and female snakes was observed. In 2003 male snakes utilized Open Bluff Faces (27.8%), Bluff side Closed Canopy Forest (17.9%) more frequently; females utilized Open Bluff Faces (20.5%), Oak Savannah (18.2%). It was determined by chi-squared analysis that snakes did not select habitat based on the proportion in which it was available and three habitat types were used less often than expected, while two were used more often than expected. Data collected in 2004 and 2005 is still being analyzed. **SSAR SEIBERT CONSERVATION**

***KARNS, DARYL R.; SUDDETH, JERRY S.; MURPHY, JOHN C.;
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Geographic variation in community composition and morphological characteristics of aquatic snakes in central Thailand

We studied geographic variation in the community composition of aquatic snakes and in the morphology of two homalopsine snake species (*Enhydris enhydris* and *Enhydris plumbea*) along a freshwater transect in central Thailand. Previous studies indicated that topography and river drainages are important influences on the composition of snake communities; these factors may influence gene flow among snake populations and contribute to patterns of geographic variation and speciation. Sites sampled included localities on the Khorat Plateau (225-230 m elevation), the rim of the plateau (408-525 m elevation), and lowland sites off of the plateau (6-10 m), a total of 7 sites. Drainage on the Khorat Plateau is to the east and the Mekong River; drainage off of the plateau to the south and west goes to the Gulf of Thailand. We collected snakes by gill nets and hand collecting and noted the composition of the snake assemblages at each site (up to 10 species at any given site, n = 484 snakes). Morphological data (standard scale counts and body size measurements) were taken and analyzed for populations of the homalopsine snakes, *Enhydris plumbea* and *Enhydris enhydris*, from different localities. We found that homalopsine snakes (up to 5 species) were abundant on the plateau and in adjacent lowlands, but that homalopsines were not part of the aquatic snake community at higher elevations on the Khorat Plateau rim. We document sexual dimorphism in *Enhydris enhydris*, but not in *Enhydris plumbea*.

We found geographic variation in some scale characters, but this variation did not clearly correspond to topographic and drainage features. We plan further analysis of geographic variation in these two species using molecular data.

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Impacts of road de-icing salt on water quality in vernal pools and the demography of amphibians

De-icing agents, primarily road salt, are applied to roads in 26 states in the United States and a number of European countries, yet the impacts of road salt on aquatic organisms remain largely unstudied. Amphibian skin is permeable to water and is important in respiration and osmoregulation, rendering some amphibians particularly sensitive to chemical contaminants. In a field study in the Adirondack Region of New York, road salt traveled at least 172 m from a highway into wetlands. Conductivity levels in roadside vernal pools in this relatively pristine environment were comparable to those in urban wetlands. Reproductive effort was lower in roadside pools for the spotted salamander (*A. maculatum*) and attributable to both conductivity and pool location relative to the road. Reduced reproduction by the wood frog (*R. sylvatica*) in roadside pools was associated primarily with pool location. Survival in embryonic and larval *A. maculatum* was reduced at moderate (500 S) and high conductivity (3000 S) levels, but those in *R. sylvatica* were affected only at high levels. Survival in *R. clamitans* was 88% or higher in both embryos and larvae at all conductivity levels, with 15% of embryos malformed at the highest level. These results suggest that road salt affects *A. maculatum* more than *R. sylvatica* or *R. clamitans*. Efforts to protect local populations of *A. maculatum* in roadside wetlands should, in part, be aimed at reducing application of road salt near these wetlands.

***KARSTEN, KRISTOPHER B.; ANDRIAMANDIMBIARISOA, LAZA;
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Courtship behavior and sexual selection in two species of chameleons in southwest Madagascar

There have been very few behavioral field studies on chameleons, particularly where their diversity is greatest, Madagascar. In southwestern Madagascar, there are several closely related, broadly sympatric species of chameleons. Despite their close phylogenetic affinities, morphology among these species is quite diverse, especially among characters that are usually sexually selected. We conducted field experiments and natural observations of courtship and agonistic behavior in two species of chameleons in southwest Madagascar, *F. labordi* and *F.*

verrucosus. *Furcifer labordi* is a species that has large sexual size dimorphism, as well as both a prominent rostral appendage and a large cranial casque in males. *Furcifer verrucosus* has large sexual size dimorphism, a large casque in males, but lacks a rostral appendage. In many chameleons, our two focal species included, female sexual receptivity and non-receptivity is easily determined by coloration. In *F. verrucosus*, males courted both sexually receptive and non-receptive females. Non-receptive females rejected all male advances, whereas sexually receptive females displayed very little rejection behavior. Male mating success was determined mostly by the ability or inability of males to physically achieve a proper grasp for copulation, not due to female rejection behavior. In male-male encounters, aggressive behaviors resulted in the clear submission of one of the participants, yielding a dominant and subordinate male. *Furcifer labordi* males courted both sexually receptive and non-receptive females, but more vigorously approached receptive females. Non-receptive female *F. labordi* rejected all male advances, whereas sexually receptive females were less predictable in their rejection behaviors, often changing from rejection to receptive or vice versa within the same courtship encounter. Male mating success was predominately determined by female behavior, not physical ability to achieve a copulatory grasp. In male-male encounters of *F. labordi*, similar to *F. verrucosus*, agonistic interactions also resulted in the decisive submission of one of the participants.

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Sharks: The skinny

How shark skin structure relates to function is still uncertain. Shark skin is covered in many tooth-like structures called denticles embedded in the dermis and projecting through the epidermis. How this structure affects the material properties is a question of interest. The two objectives of this study were to determine the differences in strength and stiffness of the skin and also to describe the mineral content between and within species. I also tested whether the material properties are correlated with degree of mineralization. Shark skin from 4 species (*Isurus oxyrinchus*, *Mustelus lunulatus*, *Prionace glauca*, and *Carcharhinus plumbeus*) was biomechanically tested and data were analyzed to compute strength and stiffness. Skin samples were then heated to 500 degrees C in a muffle furnace for 3 hours to remove organic matter. The remaining material determined mineral content, 16%, 28%, and 24%, respectively. Mineral content differed between species ($p < 0.0001$) but not within species ($p > 0.05$). Both the skin strength and stiffness differ between species ($p < 0.0001$). Stiffness ranged between 1×10^5 to 1×10^7 Pa. However, only stiffness differed within species ($p < 0.0001$), whereas strength did not ($p > 0.05$). These results suggest that mineral content, strength, and stiffness of shark skin are independent of each other. It is possible that the other skin materials, such as collagen fibers, contribute greatly to strength and stiffness. The mineralized denticles in the skin may instead be more involved in locomotion.

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Historical biogeography of *Nothonotus darters* (Percidae: Etheostomatinae).

Nothonotus darters consist of 20 recognized species occurring in the Interior Highlands, Eastern Highlands, Mobile Basin, Central Lowlands, and Mississippi Coastal Plain with at least one species endemic to each of these regions except the Central Lowlands. This wide distribution and relatively high levels of endemism make the group a good candidate for studying patterns of dispersal and vicariance in eastern North American fishes. We use a time-calibrated cytochrome b phylogeny of all *Nothonotus* and dispersal-vicariance analysis (DIVA) to assess major zoogeographic hypotheses of Central Highlands North American fishes, and specifically *Nothonotus darters*. Our results indicate the clade to be at least 20 million years old. Diversification within the clade is best explained by within highland region speciation, possibly driven through mechanisms such as the geomorphic evolution of the Tennessee River. These results indicate that relationships between disjunct highland areas, either through vicariance (e.g. Central Highlands Vicariance Hypothesis) or dispersal (e.g. Pleistocene Dispersal Hypothesis) have a limited importance in explaining the extant species diversity in *Nothonotus*. **STOYE GENERAL ICHTHYOLOGY**

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Modeling and mapping occupancy probabilities by Gopher Tortoise in Florida upland habitats

The Gopher Tortoise (*Gopherus polyphemus* (Daudin)) is the only native tortoise found east of the Mississippi River. The species has an affinity for open-canopied, upland habitats, also preferred by humans. Loss and fragmentation of habitat by human development have reduced and fragmented gopher tortoise populations. Determining the extent and configuration of remaining habitat in Florida is an important element of conserving this species. We used the landcover map from the GAP program, as well as soils and land use information, to determine the extent of potentially suitable habitat for gopher tortoises in northeast Florida. Using ArcGIS, random ground-truthing locations were distributed throughout potential habitat for determining landcover mapping accuracy, presence of gopher tortoises, and for gathering data on vegetation cover for a logistic model of habitat. Overall landcover accuracy of potential habitat was 65%, but varied by cover type. A logistic regression model by landcover was used to determine probabilities of gopher tortoise occupancy. Sandhill habitat had the highest probability of occupancy (0.90) but is not an extensive habitat. Clearcut areas had the next highest probability (0.76) but along with pine (probability of 0.56) represents an extensive habitat for gopher tortoises. No gopher tortoises were found in either upland hardwood hammock, mixed deciduous-pine, or improved pastureland (where they are likely removed by humans). A logistic model of vegetative structural variables included the understory, leaf litter and groundcover and excluded vertical cover and bare

ground. Gopher tortoises are related positively to groundcover (their food source), but negatively to understory and leaf litter. The latter variables together are likely a proxy for overall density of above-ground vegetative structure that inhibits gopher tortoise presence. This study represents an important method for evaluating the potential and realized habitat for the species through a combination of remote sensing, GIS, ground truthing.

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Polychlorinated biphenyls (PCBs) in snapping turtles of the Hudson River Superfund Site: Maternal transfer dynamics and adult endocrine effects

The upper Hudson River Superfund Site received almost a half-million kg of polychlorinated biphenyls (PCBs) over a 30-year period and remains one of the most heavily PCB-contaminated regions in the U.S. The common snapping turtle (*Chelydra serpentina*), a long-lived omnivore known to bioaccumulate persistent organic pollutants such as PCBs, is a common resident of the contaminated area. Here we present preliminary results from examinations of endocrinological correlates with PCB accumulation by adults, and maternal transfer of PCBs to offspring. The results presented here are part of a larger study investigating accumulation and effects of PCBs on snapping turtles of the upper Hudson River. Over a two-year period (2003-2004), we collected eggs and blood samples from adult turtles in the PCB-contaminated area and in nearby, relatively pristine, areas. We analyzed whole blood samples from adult turtles and egg composites for total PCB and specific congener concentrations, and samples from adults for vitellogenin, an estrogen-dependent yolk precursor. Concentrations of PCBs in adult blood tissue were related to sex, body mass, and proximity to contaminant point sources. As well, maternal blood PCB concentrations were correlated with PCB concentrations in their clutches. Whole blood PCB concentrations in adult male turtles from the contaminated area appeared to be elevated in serum vitellogenin concentrations compared to males from uncontaminated sites, although these data are preliminary at this time. Implications for organism- and population-level health will be discussed, specifically with regards to pending dredging activities at the Superfund site aimed at reducing exposure of resident organisms to PCBs.

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Stomiids without barbels III: Materials toward a revision of the Stop-light Loosejaw genus *Malacosteus* (Stomiidae: Malacosteinae)

The loosejaw dragonfish genus *Malacosteus* Ayers is revised based on a review of over 100 specimens. A new species is described from the Southern Pacific that may prove to be distributed throughout temperate waters of the southern hemisphere. This new species differs from the only valid congener, *Malacosteus*

niger, in having a smaller postorbital photophore. A brief systematic overview of Malacosteinae is presented in addition to discussing the trajectory of future research on the subfamily. **STOYE GENERAL ICHTHYOLOGY**

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The UT research collection of fishes: Past, present, and future

The University of Tennessee Research Collection of Fishes was started by Dr. David Etnier in 1965 in a region with more species of freshwater fishes than any other temperate region in the world. Since then it has grown to house roughly 11,000 cyprinid lots, 7,000 percid lots, and 4,000 centrarchid lots. Approximately 180 other families are represented in the collection, with an estimated total of 35,000 lots. Recently we have begun a computer data base of the collection holdings, and we anticipate this process will be completed in four years. The collection will be housed in a recently renovated Hessler Biology Building on the University of Tennessee campus. These new facilities include an extensive collection range, a preparation and sorting area, and a state of the art molecular biology laboratory. In addition to these latest developments, the fish collection is at the center of a new University of Tennessee Tissue Collection that aims to provide genetic resources to all researchers. With frequent, and often very substantial, deposition of specimens from the members of the UT ichthyological community, the Tennessee Valley Authority, the Tennessee Wildlife Resources Agency, and the many colleagues of Drs. Etnier and Near the UT Research Collection of Fishes is very quickly growing into what we hope will be one of the most important collections documenting the incredible temperate biodiversity of the southeastern United States.

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Role of prey-capture kinematics in the interaction between the introduced Pike Killifish and the native Largemouth Bass

Interactions between exotic and native fishes are enhanced when they share similar traits; competition is elevated when the exotic has functional specializations that enhance its performance on a particular task relative to the native. The magnitude of this interaction depends to a large extent on the degree of overlap in the niches that these species occupy. In an attempt to explore behavioral and ecological interactions between exotics and native species, we compared the kinematics of prey capture in the native Centrarchid, *Micropterus salmoides*, and the exotic Poeciliid, *Belonesox belizanus*. Fish with approximately the same standard length were filmed feeding on live fish prey and the high-speed videos were analyzed. Independent samples T-tests revealed significant differences between largemouth bass and pike killifish in kinematic variables such as length of hyoid depression and time to maximum gape (with largemouth bass having increases relative to the pike killifish), whereas other kinematic

variables (e.g., cranial elevation and attack velocity) do not differ significantly. Preliminary results also indicate substantial variability in kinematicspace (based on a principle components analysis) of the exotic compared to the native (perhaps indicating a more generalized feeding strategy of the exotic). The apparent overlap in feeding kinematicspace suggests that the exotic species is as capable of capturing fish prey as the native species. This interaction has tremendous implications for the structuring of native fish populations because of the proliferation of exotic species.

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Investigations of $\Delta^{14}\text{C}$, $\delta^{13}\text{C}$, and $\delta^{15}\text{N}$ in vertebrae of white shark (*Carcharodon carcharias*) from the eastern Pacific

Age and growth estimates from vertebral band counts of the white shark (*Carcharodon carcharias*) from the eastern Pacific Ocean indicate a relatively long life and slow growth rate; however, these estimates have not been validated. To obtain reliable age, growth, and longevity estimates useful for stock assessment and fishery models, validation of age estimation is essential. However, because not all sharks deposit annual growth zones in their vertebrae, nor are they easily discernable in all species; it is necessary to validate the periodicity of these growth zones by an independent method. Radiocarbon (^{14}C) age validation uses the discrete ^{14}C signal produced from thermonuclear testing in the 1950s and 1960s retained in skeletal structures as a time-specific marker. The goal of this study was to evaluate validation of age estimation procedures and gain a better understanding of the carbon source to white shark vertebrae. Annual growth zones of vertebrae spanning the 1930s to 1980s were cored and analyzed for $\Delta^{14}\text{C}$, $\delta^{13}\text{C}$, and $\delta^{15}\text{N}$. Stable isotopes provided useful trophic information, however validation of age estimates was confounded by the combined influence of the dietary source of carbon to the vertebrae, large-scale movement patterns of white sharks, and steep radiocarbon gradients present within the northeast Pacific Ocean. This work was performed, in part, under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

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Community structure of the resident and nomadic shark populations, Bimini, Bahamas

A twice-monthly long-line schedule has been implemented at Bimini, Bahamas (25°44N, 79°16W) since July 2003. Designed to sample the resident and nomadic adult shark populations and closely match the methodology of past research expeditions between 1981 and 1989, thus allowing comparisons between catches. Five lines, approximately 400m in length are set, four running north to south to the east of the main lagoon; the fifth in a new location each time. The bottom-set main lines are anchored at each end and have 15 baited gangions interspersed with floats, checked every three-five hours. Captured specimens are secured to the boat, measured (pre-caudal, fork and total length) and individuals over 140cm fitted with a NOAA/NMFS M-type dart tag. All lemon sharks (*Negaprion brevirostris*) receive a PIT tag and a DNA sample is taken. Eight species, *Carcharhinus acronotus*, *C. leucas*, *C. limbatus*, *Ginglymostoma cirratum*, *Galeocerdo cuvier*, *N. brevirostris*, *Rhizoprionodon terraenovae*, *Sphyrna mokarran*, have been captured in the current regime, whereas 13 species were recorded during the 1980s campaign. The four dominant populations, as proportions of total catch, are *G. cirratum* (34%), *C. limbatus* (25%), *G. cuvier* (22%) and *N. brevirostris* (14%). This is in stark contrast to the 1980s catches, *G. cirratum* (12%), *C. limbatus* (2%), *G. cuvier* (7%) and *N. brevirostris* (74%), with the latter displaying an alarming 83% decline in CPUE over the past 20 years. Of the present populations *N. brevirostris* and *G. cirratum* show the highest rates of recapture, 33% and 9% respectively, suggesting that these dominate the resident sharks, while *C. limbatus* and *G. cuvier* dominate the nomadic. Results further suggest the apparent massive decline in *N. brevirostris* may be due to local anthropogenic influences, highlighting the urgent need for an in-depth investigation into the specific causes for these drastic changes in shark assemblages.

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Life histories of the endangered *Etheostoma chermocki* and its sister species, *E. bellator* endemic to the Black Warrior River system

The federally endangered vermilion darter (*Etheostoma chermocki*) is endemic to a single stream, Turkey Creek, in the Black Warrior River system, Mobile Basin, Alabama. Preserved specimens obtained from October 1969 to January 2000 were

evaluated to determine life history characteristics. Standard length was significantly correlated with body mass, gonad mass, and clutch size. Sex ratio (2:1) was in favor of females. Length frequency distribution and enumeration of otolith annuli revealed four different age classes (0 to 3). Vermilion darters matured at the end of the first year of life. Gonadosomatic index indicated reproduction occurred from March to June. Mean clutch size was 65 oocytes per female and mean oocyte diameter was 1.14 mm. Vermilion darters are generalist benthic invertivores, predominantly consuming larval chironomids (midges), tipulids (crane flies), and hydropsychids (caddisflies). Diet breadth (prey richness) was greatest during warmer months and least during colder months. While preserved specimens of *E. chermocki* provided valuable insights into the life history of this endangered species, samples were missing for some months. Additionally, studies marking individual darters to determine population size, movement, and number of clutches per female are not permitted on *E. chermocki* until this technique can be shown to be non-injurious. *Etheostoma bellator*, the sister species to *E. chermocki*, represents an ideal surrogate for use in such studies. Monthly sampling of *E. bellator* is ongoing from Gurley Creek, a stream adjacent to Turkey Creek. Preliminary life history information from preserved specimens of *E. bellator* shows that it has very similar life history traits to *E. chermocki*. This strengthens our position that the life history of *E. bellator* must be determined, and that a better understanding of the autecology of this surrogate (i.e. sister) species will facilitate more effective conservation planning for *E. chermocki*.

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Habitat use and spatial distribution of a southeastern population of *Gopherus polyphemus*

Gopher tortoise ecology, including life history, feeding and habitat utilization, is poorly understood in the rapidly developing South Florida end of its range. I studied a large population of *G. polyphemus* in the nature preserve on the Boca Raton campus of Florida Atlantic University. The areas around the preserve are undergoing rapid development in response to increasing student needs. Hence, there is now "competition" for land between natural ecosystem requirements and human needs. This study reassesses the population of gopher tortoises living on the FAU Nature Preserve (26° 23' N, 80° 7' W) associated with the increase of land development that has occurred over the past four decades. Research conducted in the late 1980s and early 1990s indicated FAU had a large, viable *G. polyphemus* population. The current population is probably viable; however, the results of this study show a population reduction. Here I report on this reduced population, habitat use, and environmental factors that correlate with burrow location at this southeastern Florida site. Burrow surveys and animal captures were conducted from May-June 2003 and May-August 2004. Burrows were marked and their positions recorded using GPS (sub-meter accuracy). The data were mapped for spatial analysis. Nonparametric statistical tests were conducted to determine relationships between burrow location and several environmental characteristics such as edge, elevation, and soil type. I found that burrow locations did not differ in elevation or soil type at the FAU preserve. The densest concentrations of burrows were located at the edges of the preserve in areas of patchy ground cover. There is minimal elevated ground cover in these areas. These vegetation characteristics correspond with gopher tortoise habitat

preferences described in the existing literature.

***KINGSBURY, BRUCE A.; SAGE, JOSEPH R.; MANNING, JENNIFER V.**

Center for Reptile and Amphibian Conservation and Management, Department of Biology, Indiana-Purdue University, Fort Wayne, IN 46805-1499, USA

Barriers, real and imagined: Insights into habitat management for the imperiled Eastern Massasauga

The Eastern Massasauga (*Sistrurus c. catenatus*) is a Candidate for listing as federally Threatened and is protected in all states and provinces in which it occurs. We draw on radio telemetry observations from several sites over multiple years to provide commentary on refugia and barriers. Massasaugas will find, use, and persist in habitat refugia, then expand back into restored areas. Islands of habitat should be planned into restoration and construction designs. Protracted activities around refugia increases the time dangers are present for the snakes, so low risk impacts have more substantial deleterious effects over time. Populations may be more vulnerable than initially evident as a consequence of crowding and differential mortality of gravid females. Gravid females may select to position themselves in disturbed areas as they search for advantageous microclimates for gestation. Barriers may be more a consequence of inhibition of movement, rather than being truly impermeable. Paved roads, even with very low traffic rates, present almost complete barriers. Gravel roads appear to be less restricting. Extensive forest may provide a more complete barrier than we thought, but small rivers are readily navigated.

***KINLAW, AL; CONYERS, LAWRENCE**

(AK) Department of Wildlife Ecology and Conservation, 303 Newins-Ziegler Hall, University of Florida, Gainesville, FL 32611-0430, USA; (LW) Department of Anthropology, University of Denver, 2000 E. Asbury Street, Denver, CO 80208, USA

First images of gopher tortoise (*Gopherus polyphemus*) burrows using ground penetrating radar

Ground penetrating radar (GPR) is a non-invasive technique that can quickly determine the physical dimensions and complexity of air voids in the ground such as animal burrows. We chose the burrows of the gopher tortoise (*Gopherus polyphemus*) to examine with GPR because its burrows are relatively simple and large enough such that images could be captured with the resolution of our system. Moreover, since populations of this species are declining, and its burrows play a critical role in the ecological processes of upland vegetative communities of the southeastern U.S, data on this essential component of its life history are urgently needed. In the Ocala National Forest, FL, we mapped 14 burrows, 6 in the scrub and 8 in the sandhills community. The depth and turns of each burrow were easily imaged using this method; 9 of the burrows turned left, 3 turned right, and 2 were fairly straight. Several of the turns had a corkscrew or spiral configuration. We compare data collected manually on length, height, and volume of burrows with the same metrics determined by GRP, and present 3 dimensional images illustrating the architecture of the burrows. We discuss the

advantages, limitations, and misconceptions involving the use of GPR in applications such as this, and compare GPR with other methods used to examine the burrows, such as excavation, foaming, and camera scanning.

KINZIGER, ANDREW P.; NEELY, DAVID A.

(APK) Department of Fisheries Biology, Humboldt State University, One Harpst Street, Arcata, CA 95521, USA; (DAN) Department of Biology, Saint Louis University, 3507 Laclede Avenue, St. Louis, MO 63103, USA

Molecular systematics of the genus *Cottus* (Scorpaeniformes: Cottidae)

A recent phylogenetic hypothesis for the genus *Cottus* based on 1914 bp of mitochondrial DNA (cytochrome b and ATPase 8 and 6) supported non-monophyly of *Cottus* with respect to the Baikalian sculpins and the genus *Leptocottus* and supported recognition of five well supported clades (BS > 90 and PP > 0.95) within the genus *Cottus*, referred to as the Cottopsis, Uranidea, Baikalian, *Cottus* and *Cephalocottus* clades. That analysis however failed to place ten *Cottus* species into any clade and the relationships among many of the well-supported-clades remained unresolved. In an effort to resolve these issues, we compiled nuclear (S7RP, TMO-4C4, Calmodulin and CK) and mitochondrial (cytochrome b and ATPase 8 and 6) sequence data (about 3500 aligned bp) from representatives of all well-supported-clades and all ten *Cottus* species not assigned to a clade. Parsimony analysis of the combined mitochondrial and nuclear data set provided additional structure to the phylogenetic hypothesis however many nodes still remained unresolved.

***KIRBY, LAUREN E.; BURGHARDT, GORDON M.**

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A comparative study of behavior in neonate garter snakes of two species, *Thamnophis butleri* and *T. radix*, in an area of potential hybridization

A population of *Thamnophis butleri* in southeastern Wisconsin has recently been listed as Threatened by the Wisconsin Department of Natural Resources. One of the possible reasons for the decline of *T. butleri* in this area is pressure from a closely related species, *T. radix*. The possibility of hybridization between *T. butleri* and *T. radix* has received recent attention because *T. butleri* is threatened in the area where the hybridization may be occurring. This study addresses the issue using the behavior of neonatal *T. butleri* born to females originating from areas where the species' ranges overlap (southeastern Wisconsin), as well as from areas outside the range of *T. radix* (Michigan and northern Ohio). Gravid females were collected from 4 counties in southeastern Wisconsin, with the southernmost county closest to the range of *T. radix*. We examined antipredator behavior, prey chemosensory responses, and other behavioral and morphological traits. Differences were found in antipredator behaviors across the different counties, with snakes from the county closest to the range of *T. radix* striking more frequently. Chemosensory preferences of the snakes also differed across counties. Snakes from the southernmost county showed a chemosensory preference for fish over worms, whereas snakes from the northern part of the range showed a

chemosensory preference for worms over fish. Hence, the behaviors of *T. butleri* from the southern part of their range in southeastern Wisconsin, closer to the range of *T. radix*, are more like *T. radix* than the behavior of *T. butleri* elsewhere in their range.

***KLEIN-MAJORS, SEASON; CROWE, MARY**

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Correlations between the distributions of the Atlantic Stingray (*Dasyatis sabina*) and the Southern Stingray (*Dasyatis americana*) and salinity profiles in Winyah Bay, South Carolina

Both the Atlantic, *Dasyatis sabina*, and the Southern stingray, *Dasyatis americana*, are common estuarine species found in South Carolina. Both species are found in S.C. sounds, estuaries and rivers at some part of the year. *D. sabina* has been found to frequent and even reside in low salinity waters while *D. americana* prefers waters that are marine salinities. The purpose of this study was to determine if the existing distributions of either or both *D. sabina* and *D. americana*, in Winyah Bay, S. C., vary according to salinity profiles. Winyah Bay watershed is the third largest watershed along the east coast of the United States and it serves as the freshwater drainage of four major rivers. Salinity within the bay can vary dramatically with up to 20 ppt difference between the surface and bottom water masses depending on the amount of fresh surface water entering the bay through the four rivers. Stingrays were captured May through September using longlines with 16/0 hooks for adults and 12/0 hooks for juveniles. In addition, lines were set during both tidal cycles and set 60 min. for adults and 30 min. for juveniles. This pilot study showed distinct differences between *D. sabina* and *D. americana* for salinity preferences. Initial results showed *D. americana* seemed to prefer higher salinities in the lower reaches of the bay (21-32 ppt), low tide and high tide respectively, while *D. sabina* preferred lower salinities in the upper portion of the bay (9-16 ppt) where the four major rivers input freshwater. *D. americana* exhibited average CPUE's of 8.5 in salinities of 19-25 ppt, whereas *D. sabina* exhibited average CPUE's of 12.7 in salinities of 5-10ppt. This year this study will be continued for a second sampling season in order to further compare these two stingrays within this estuary.

***KLOWDEN, GREGG S.; MOULTON, MICHAEL P.**

University of Florida, Dept. of Wildlife Ecology & Conservation, P.O. Box 110430, Gainesville, FL 32611-0430, USA

Demography of non-indigenous geckos in southwest Florida

Non-indigenous geckos have become common in many subtropical and tropical regions of the world. In Florida, USA at least a dozen species have been reported. Most of these occur as isolated records or small populations however a few are widely distributed. Among the most widespread are *Hemidactylus garnotii*, reported from most counties in peninsular FL and *H. mabouia*, reported from many southern and coastal counties. It has been hypothesized by many

researchers that *H. mabouia* is displacing *H. garnotii* however little is known about these species making it difficult to examine the effect of their interactions. In an effort to understand these species I will present results of multi-year demographic analyses of *H. garnotii* and *H. mabouia* in southwest Florida, USA.

***KLUEH, SARABETH; MULLIN, STEPHEN J.**

Eastern Illinois University, Department of Biological Sciences, Charleston, IL 61920, USA

Population ecology of the Jefferson salamander, *Ambystoma jeffersonianum*, in Illinois

Amphibian populations utilizing small isolated wetlands are often small in size, have little to no contact with other populations, and are susceptible to stochastic extinction processes. The persistence of such populations can only be ascertained by obtaining data that allow the prediction of the population's growth, trajectory, and capacity to achieve a sustainable size. The Jefferson salamander, *Ambystoma jeffersonianum*, is a state-threatened species, occurring at fewer than 15 ponds within Illinois, individuals at a pond in the east-central part of the state were captured using a drift fence-pitfall trap array, then sexed, measured for SVL, and marked using a unique combination of toe clips. We obtained the number of egg masses, average percentage of successfully hatched eggs, and number of juveniles leaving the pond. All data was then entered into a life history table and used to develop a population model. Information obtained from the model was used to predict the life history stage most critical to the survival of the population. We suggest appropriate management strategies to prevent the local extinction of this population.

***KNAPP, CHARLES R.; OWENS, AUDREY K.; IVERSON, JOHN B.**

(CRK) Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL 32611, USA; (AKO) Warnell School of Forest Resources, University of Georgia, Athens, GA 30605, USA; (JBI) Department of Biology, Earlham College, Richmond, IN 47374, USA

Geographic variation in nesting behavior and reproductive biology of an insular Bahamian iguana (*Cyclura cyclura*)

Comparisons among geographically separated populations of wide-ranging species are particularly useful in elucidating variation in reproductive characteristics resulting from proximate and ultimate causes. Variation in nesting behavior often is omitted from comparative studies in favor of reproductive parameters, survival rates, or morphometrics. We incorporated variation in nesting behavior with our multi-year, geographic life-history study of the Bahamian iguana (*Cyclura cyclura*) inhabiting two distinct island systems varying in area, topography, and rainfall. Reproductive biology and nesting ecology studies of *C. c. cyclura* were conducted on Andros Island (ca. 6,000 km²) and data compared with *C. c. inornata* inhabiting two cays (each < 4 ha) in the Exuma Island chain. Although iguanines are fairly uniform in their nesting tactics, the Andros iguana deviated from the standard model by its predominant use of termitaria as incubation chambers, presumably due to limited soils

typically used for nesting. Oviposition for the Andros population was initiated in early May; nearly six weeks earlier than the Exuma populations. On Andros, mean incubation temperatures in termitaria were 1 °C warmer than mean temperatures in sand nests of the Exumas. Mean duration of incubation was 76 d for Andros nests versus 83 d for nests in the Exumas. Clutch size was positively related to body size for both populations. However, despite being larger in body size, ANCOVA revealed that Andros iguanas deposit larger clutches of larger eggs than Exuma iguanas. Interestingly, egg mass was positively correlated with body size on Andros but not in the Exumas. The larger body sizes of Andros iguanas reveal differences in absolute variation that may be missed when investigating populations with smaller body sizes. We suspect that much of the difference in body size, clutch size, clutch mass, and egg mass between the Andros and Exuma populations is a result of density-dependent resource availability. **SSAR SEIBERT ECOLOGY**

KNAPP, ROSEMARY

University of Oklahoma, Dept. Zoology, Norman, OK 73019, USA

Neuroendocrinology of reproductive behavior in centrarchids

Two features of centrarchid reproductive behavior have received a fair amount of attention relative to questions of neuroendocrine mediation: alternative male reproductive tactics and male parental care. This presentation will summarize our current understanding of how various hormones, particularly steroids, contribute to the expression of reproductive behavior in centrarchids. I will identify what I believe are significant gaps in our current understanding of hormone-behavior relationships in this family. These include almost no information on the neuroendocrine mediation of female reproductive behavior. Finally, I will highlight the types of questions for which centrarchids are particularly well-suited due to various features of their mating systems and life history.

KNIGHT, C. MICHAEL

University of Memphis, Department of Biology, Memphis, TN 38152, USA

How does natural selection influence the outcome of a biological invasion? Interactions between larval Cuban treefrogs and native frogs in Florida

Biological invasions are having a major impact on the structure and function of ecosystems worldwide. Despite many well-documented invasions, the outcome of species interactions in an invaded community remains largely unpredictable and warrants empirical testing. In Florida, the Cuban Treefrog (*Osteopilus septentrionalis*) is a superb colonist and a significant driver of amphibian community dynamics at the adult level. Where Cuban Treefrogs have invaded, population reductions and localized extirpations of native anurans have ensued. However, amphibian populations are most strongly regulated during the larval stage and yet the impact of the Cuban Treefrog in the larval stage remains an open and important question. Testing hypotheses regarding the selective forces influencing species interactions at the larval level, I rear tadpoles of the Cuban

Treefrog and an ecologically relevant native species (e.g. Squirrel Treefrog, *Hyla squirella* and Southern Toad, *Bufo terrestris*) in artificial ponds under a randomized replacement-series experimental design. Data collected and analyzed at metamorphosis include body mass, larval period duration, growth rate, and percent survival - characters regarded as valid metrics of fitness. My research to date indicates that Cuban Treefrogs negatively impact native anurans at the larval stage, however, certain factors (e.g. location of ponds and priority effects) strongly influence species interactions, tipping the natural balance and altering final community structure. Research currently underway supplements existing data by measuring influences of predation, hydrologic regime, and asymmetric population densities on invasion outcomes. Results will be used to develop a model of invaded community dynamics and aid attempts to manage biological invasions.

KNOUFT, JASON H.

University of Colorado, Department of Ecology and Evolutionary Biology, University of Colorado Museum of Natural History, UCB 265, Boulder, CO 80309, USA

The relationship between body size evolution and regional species assemblages in Centrarchidae

Body size is correlated with most life-history characteristics as well as with patterns of species diversity. Consequently, examination of body size diversification in the context of regional species assemblage composition is appropriate and can offer a broad perspective on the general factors regulating species diversity. Studies investigating evolutionary patterns of body size diversification are relatively common, as are studies investigating ecological factors influencing regional species distributions. Nevertheless, the integration of evolutionary information with broad-scale ecological data to explain species distributions has received less attention. This is noteworthy considering that species distributions are a result of both evolutionary history as well as ecological sorting in local communities. Using information on the evolutionary relationships within Centrarchidae, I examined patterns of body size evolution within the family. In conflict with recent work, I found no consistent directionality in the evolution of body size among species. Nevertheless, centrarchid species are not distributed randomly across North America with respect to body size. Consequently, understanding the influence of ecological conditions across North America may provide insights into regional body size diversification within this group. Geographic information system (GIS) based analyses reveal that regional patterns of body size and species diversity in North American fishes are influenced by current ecological conditions as well as evolutionary history. Using similar analyses, I will discuss the influence of broad-scale environmental conditions on historical patterns of body size diversification among centrarchids across North America.

***KOBZA, MAC; COOK, MARK; CALL, ERYNN**

South Florida Water Management District, Everglades Research Division, 1480 Skees Road, West Palm Beach, FL 33411, USA

Nonindigenous fish in the Everglades: Potential ecological impacts

Anthropogenic stresses over the past half century have considerably impacted the function of the Everglades ecosystem, causing fish populations to decline and altering their community structure. A potential threat to restoration of the Everglades fish community is the increasing number of nonindigenous fish species in the southern Florida drainage. To date, 76 nonindigenous freshwater fish species have been identified and 35 have established breeding populations. Canals bisecting and surrounding the Everglades serve as a thermal refuge and conveyance for nonindigenous fishes, and these canals potentially permit access to the Everglades marsh. Despite the possible negative effects of nonindigenous fish to ecosystem function, their presence in the Everglades marsh and potential effects on marsh community dynamics have received little attention. In this study, an initial survey was conducted to detect the presence and relative abundance of nonindigenous fish species in an area of Water Conservation Area 3A adjacent to the L-67A canal. A goal of our study was to determine if nonindigenous fish distribution was limited by thermal constraints and proximity to a thermal refuge (L-67A canal), and if not, how far into the marsh these species have invaded. We will also relate nonindigenous fish relative abundance and biomass to native fish community data and discuss potential ecological impacts on the Everglades ecosystem.

KOLBE, JASON J.

Washington University, Dept. Biology, St. Louis, MO 63130, USA

Evidence for multiple introductions in some *Anolis* lizard invasions of Florida

The increasingly common problem of non-native species introductions brings with it a considerable economic and biological cost. Knowledge of the introduction history is vital to invasive species management and prevention of future introductions. Here, I use DNA sequence data to reconstruct the invasion histories of *Anolis* lizards introduced primarily to Florida. These lizards are native to the Caribbean and introduced to the U.S. as well as other parts of the world. I focus on three questions related to these introductions: 1) where do haplotypes from introduced populations originate?, 2) what is the route of colonization for introduced populations?, and 3) how does population structure differ between native and introduced ranges? For *Anolis sagrei*, over 99% of individuals sampled from introduced areas have mtDNA haplotypes identical or closely related to those found in Cuba. Moreover, these introduced haplotypes originate from multiple geographically and genetically distinct areas of Cuba, strongly suggesting multiple independent colonization events. Despite this result, most colonization events do not appear to have occurred directly from Cuba. Instead, recent *A. sagrei* introductions to Hawaii, Grand Cayman, Taiwan, and Grenada are the result of secondary introductions from Florida, the most widespread introduction. Indeed, all haplotypes from other non-native populations sampled (except Jamaica) are identical or nearly identical to

haplotypes sampled in Florida. Finally, native *A. sagrei* populations are strongly structured geographically, whereas the majority of genetic variation occurs within, rather than among, introduced populations. Results from other introduced *Anolis* lizards in Florida are similar to *A. sagrei* in that multiple introductions are common. This occurs despite highly restricted non-native distributions for all introduced *Anolis* except for *A. sagrei*. These results illustrate that multiple introductions are quite common and in some instances can transform among-population genetic variation in the native range to within-population variation in introduced populations.

***KONINGS, ADRIANUS F.; STAUFFER JR., JAY R.**

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Morphological and behavioral support for the break-up of the genus
Pseudotropheus

Pseudotropheus has been a catch-all genus for a large number of the small rock-dwelling cichlids (mbuna) of Lake Malawi. At one point, more than 200 recognized forms were assigned to this genus, 39 of which were officially described. In 1984, Trewavas suggested a subgenus, *Tropheops*, to include those members that have a strongly decurved dorsal head profile, a retrognathous lower jaw, and 6-9 vertical bars below the dorsal. In 1997, Stauffer et al. suggested the genus *Metriaclima* for those species that have isognathous jaws and a moderately sloped ethmo-vomerine block with a swollen rostral tip. Underwater observations of the feeding behavior of numerous members of *Pseudotropheus* revealed that three main categories of techniques can be distinguished: 1) pickers – single bites to retrieve fare (algae or invertebrates), 2) rakers – repeated raking through the biocover retrieving algae, and 3) pullers – repeated seizing and pulling of algal strands, often with sideward jerks. All current members of *Metriaclima* appeared to be rakers and all current members of *Tropheops* are pullers. The type species of *Pseudotropheus*, *P. williamsi*, is a picker (feeding on flies on the water surface) and other members of the genus, thus far examined, feed by picking at the substrate. Morphological examination of neurocrania showed that the rakers (*Metriaclima*) have a vomer inclination of about 40°, the pickers an inclination of about 60°, and that the vomer inclination of the pullers (*Tropheops*) is about 80°. We reformulated the diagnoses of the three genera in question based on these observations.

***KOWALSKI, AMY; MILTON, SARAH**

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Specific dynamic action in hatchling and juvenile green (*Chelonia mydas*)
and loggerhead (*Caretta caretta*) turtles

Specific dynamic action (SDA) describes a post-prandial increase in oxygen consumption that varies according to surrounding temperature and ingested amounts of protein, carbohydrate and fat. Many scientists agree that most of the energy is allocated to post-absorptive effects, involving growth and maintenance,

and not simply digestion. SDA and growth in hatchling sea turtles is of special interest because they are highly active animals with an adjustable metabolism and they experience drastic changes in diet, oxygen availability and habitat in the first several months of life. As more energy is devoted to SDA, less energy is available for other activities. This study was to determine how SDA relates to growth in loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles and whether it decreases as the turtles make these early life transitions. SDA was determined in 7 individuals of each species at one week, and 1, 2, & 3 months after hatching. Metabolic rate was determined by measuring oxygen consumption (VO₂) in a closed circuit metabolic chamber. Turtles were fasted for two days, fed a known amount of food, and monitored at various time points. Green turtles showed a higher VO₂ and SDA than the loggerheads.

***KOZAK, KENNETH H; BLAINE, RUSSELL A.; LARSON, A.**

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Gene trees corroborate the geological history of North American drainage basins

Stream-dwelling populations in eastern North America have experienced dramatic shifts in major drainage patterns that structure their geographical patterns of gene exchange. We combine traditional molecular phylogenetic, matrix correspondence, and population genetic approaches to investigate the relationship between geographic patterns of genetic fragmentation in the two-lined salamander species complex and the geological history of drainage systems. Patterns of phylogeographic divergence in the group show strong spatial and temporal congruence with historical, rather than contemporary drainage connections. Geographic patterns of mtDNA haplotype variation identify 13 population-level lineages, several of which form secondary contact zones along historical drainage lines. Our molecular genetic results reinforce geological and faunistic evidence for composite origins of major eastern North American drainage systems.

***KRABBENHOFT, TREVOR J.; COLLYER, MICHAEL L.; QUATTRO, JOSEPH M.**

(TJK, JMQ) Department of Biological Sciences, University of South Carolina, Columbia, SC 29208, USA; (MLC) Iowa State University, Department of Ecology, Evolution, and Organismal Biology, Ames, IA 50011, USA

Conservation genetics of the pinewoods darter, *Etheostoma mariae* (Teleostei:Percidae)

Pinewoods darters, *Etheostoma mariae* (Teleostei:Percidae), are confined to the upper reaches of the Little Pee Dee and Lumber Rivers in the Carolina Sandhills. Habitat degradation has led to extirpation of this species at several sites, and it is currently a federal species of concern. We employed nuclear and mitochondrial markers to assess patterns of genetic variation in this species. Population genetic analyses reveal deep gene genealogies between Lumber and Little Pee Dee Rivers and their tributaries. These data support the designation of two management units (MUs - one each from the Lumber and Little Pee Dee Rivers

and their respective tributaries), and highlight the importance of managing the two populations independently.

KRAUS, FRED

Bishop Museum, 1525 Bernice St., Honolulu, HI 96817, USA

Invasion pathways for alien reptiles and amphibians

Drawing on a global database of more than 1600 alien reptile and amphibian introductions, I identify the major pathways through which these organisms have spread beyond their native ranges since the 1850s. The rate of alien reptile and amphibian invasion has been growing approximately exponentially since the 1850s. Ten pathways have been involved but only six are of any real importance in accounting for alien reptile and amphibian invasions. Movement via cargo shipments and the pet trade are overwhelmingly responsible for reptile and amphibian introductions but the importance of each has varied taxonomically, temporally, and geographically. Efficiency of establishment has varied taxonomically, varied by pathway, and varied temporally within each pathway. Most introductions and most successful establishments have involved frogs and lizards. Successful establishment is relatively more likely on islands than on continents. The rate of introduction and establishment of alien reptiles and amphibians shows no sign of abating and this is due to a variety of social factors, including meaningless laws that are species-focused instead of pathway-focused and widespread attitudes that arrogate to individuals supposed rights to behavior whose costs are externalized across society but little understood by it.

***KRIGER, KERRY M.; HINES, HARRY B.; HERO, JEAN-MARC**

(KMK, JMH) Griffith University, School of Environmental and Applied Sciences, PMB 50 Gold Coast Mail Centre, QLD 9726 Australia; (HBH) Queensland Parks and Wildlife Service, Conservation Resource Unit, Moggill, Queensland, Australia

Techniques for detecting chytridiomycosis in wild frogs: Comparing histological with real-time Taqman PCR

Chytridiomycosis is a lethal disease of amphibians associated with mass mortalities and population declines worldwide. An accurate, non-invasive technique for detecting chytridiomycosis is urgently needed to determine the current geographical distribution of the disease, and its prevalence in wild amphibian populations. Diagnosis to date has relied largely on histological methods, which are time-consuming, require a toe-clip, and yield many false negatives. Here we evaluate the reliability of a recently devised, rapid, non-invasive, Taqman PCR assay. We sampled 104 wild *Mixophyes iteratus* by both a skin swab for use in the Taqman PCR analysis, and a toe-clip for examination by histological methods. The Taqman PCR assay was nearly three times more sensitive than was histology, detecting chytridiomycosis infection in at least 19.1% of frogs (histology detected infection in no more than 6.7% of frogs). We conclude that the swabbing/Taqman PCR technique is the more reliable means of detecting chytridiomycosis in wild amphibians, and that it precludes the need for toe-clipping as a means of sampling for the presence of the disease in future surveys. **SSAR SEIBERT CONSERVATION**

KRYSKO, KENNETH L.

*Florida Museum of Natural History, Division of Herpetology, University of Florida,
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Problems with introduced amphibians and reptiles in Florida: It's no longer just a tiny gecko!

While studying biological invasions of amphibians and reptiles in Florida for more than a decade, my colleagues and I have now documented 42 established exotic herpetofaunal species, including one crocodylian, one turtle, three frogs, three snakes, and 34 lizards. Before 1940, most non-native herpetofaunal species in Florida were introduced accidentally via cargo. However, despite a Florida Law that makes it illegal to release any non-native animal in the state, nearly all exotic herpetofaunal species documented after 1940 were introduced illegally via the pet trade. Because many pet owners and residents in Florida do not believe exotic species threaten Florida's environment or its native species, we carried out a diet study on the Black Spiny-tailed Iguana (*Ctenosaura similis*) from Key Biscayne and Gasparilla Island to test this hypothesis. We documented this exotic lizard feeding on 19 plants (16 native and three non-native), including the Curacao Bush (*Cordia globosa*), a state listed endangered plant species, and Brazilian Pepper (*Schinus terebinthifolius*), a highly invasive non-native species. Additionally, we documented 17 invertebrates (all native) and two vertebrates (both non-native) in its diet. Furthermore, because *Ctenosaura similis* eats many of the same plants and occupies burrows of the Gopher Tortoise, *Gopherus polyphemus*, this exotic lizard may also be competing with this protected turtle species. With the more recent documentation of established exotics with potentially greater negative impacts, including Nile Monitors (*Varanus niloticus*) and Burmese Pythons (*Python molurus*), it is clear that current laws and enforcement are inadequate and additional exotic species should be expected to become established in the future.

***KUBICKI, BRIAN; GAGLIARDO, RONALD W.**

(BK) Costa Rican Amphibian Research Center, Apartado 81-7200, Siquirres, Provincia de Limon, Costa Rica; (RG) Atlanta Botanical Garden, 1345 Piedmont Avenue, Atlanta, GA 30309 USA

Amphibian diversity and conservation in Guayacán, Limón Province, Costa Rica

The amphibian diversity of Costa Rica is one of the richest on the planet. The countries Brazil and Colombia are currently recognized as the two most amphibian diverse places in the world but, when comparing their sizes, Costa Rica is shown to have a much richer diversity in total species per 1,000 sq. km of national territory. Brazil has 731 species, but only 0.086 per 1,000 sq. km. Colombia with a total of 698 species only has 0.6 per 1,000 sq. km., but Costa Rica with 179 species has 3.5 per 1,000 sq. km. Herein we share the amphibian richness of a relatively unknown area on the Caribbean versant of Costa Rica Guayacán. The total number of amphibians for that area makes it the richest in

Costa Rica, with 63 known species. Also discussed are aspects of the conservation status of Guayacán, and projects being conducted by the Costa Rican Amphibian Research Center and the Atlanta Botanical Garden for the goals of preservation of biodiversity.

KUCH, ULRICH; *SASA, MAHMOOD; MEBS, DIETRICH

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Phylogeny, diet and snake venom evolution: the case of Australopapuan blacksnakes (Elapidae: *Pseudechis*)

Snake venoms are a rich source of biologically active peptides and proteins. Variability of snake venom composition is extensive and has been proposed to be influenced by differences in diet within and between species. Here we combine qualitative and quantitative analyses of snake venoms, phylogenetic inference, and functional studies to address the question whether venom evolution within an Australopapuan clade of elapids is the result of adaptive pressure due to differences in diet, or rather reflects shared ancestry. Blacksnakes (*Pseudechis*) inhabit most of Australia and southern New Guinea where they occupy diverse habitats. In eastern Australia, *Pseudechis porphyriacus* is known to largely prey on frogs, *Pseudechis guttatus* has a more balanced diet, and *Pseudechis colletti* from the arid interior of Queensland predominantly eats mammals. *Pseudechis papuanus* from New Guinea also prefers frogs. We inferred their relationships based on mitochondrial cytochrome b and ND4 sequences. *Pseudechis porphyriacus* is the highly divergent sister taxon of all other taxa of *Pseudechis*, whereas (*P. papuanus* (*P. colletti*, *P. guttatus*)) are closely related. In congruence with phylogeny and estimated divergence times, analysis of venoms by on-line high-performance liquid chromatography/electrospray-mass-spectrometry revealed virtually identical elution profiles with several shared masses between the venoms of *P. colletti* and *P. guttatus*, which were collectively more similar to *P. papuanus* than to *P. porphyriacus*. The venoms of all species were much less toxic for frogs (*Smilisca sordida*) than for mice. Toxicity for mice did not vary greatly between venoms. *Pseudechis guttatus* and *P. porphyriacus* venoms were the least toxic for frogs, and *P. colletti* venom was not the most toxic for mice. We interpret these data as evidence against diet changes exerting a strong adaptive pressure on the venoms of these large elapids.

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Dimorphism and resource use of male and female Swinhoe's Tree Lizard, *Japalura swinhonis*

The phenomenon of sexual dimorphism can be observed in various taxa. There are also a great number of studies which described this widespread phenomenon. However, relatively few studies established a link between different body plans and resource use of the two sexes. Finding the relationship

between morphological and ecological differences may help in our understanding of the underlying selection pressure driving the evolution of sexual dimorphism. In this study I measured snout-to-vent-length (SVL) and certain body parts of male and female Swinhoe's tree lizards and also examined their perching habitat and diet. The results showed that male and female Swinhoe's tree lizards differed significantly in their SVL. Males are larger than females. Perch height of males and females was also different. Males were mostly observed perching at height between 1 to 2 meters; while females were mostly observed perching at height between 0 to 1 meter and in no case were observed perching at height above 2 meters. Differences in perching habitats between two sexes also resulted in differences in diet composition. Females consumed a considerable amount of millipedes, which were never found in the stomachs of male lizards. The difference in perch height is probably due to different ecological activities that male and female lizards engaged in. Because males have to defend their territories, higher places provide a better view of its territory and makes displays conspicuous to other males. For females, on the contrary, it is advantageous to be cryptic, especially when carrying eggs. Different selective pressures acting on male and female lizards may have shaped different body plans between two sexes, which further resulted in differential resource use.

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Effects of guided turtle walks on nesting behavior and clutch success of the Loggerhead Turtle (*Caretta caretta*) on Bald Head Island, North Carolina

A population of loggerhead turtles (*Caretta caretta*) nesting on Bald Head Island, North Carolina was studied to determine if "turtle walks", i.e. observation of nesting turtles by naturalist-led tour groups, affected nesting behavior. Seven stages of nesting (ascent, digging of pit, digging of egg chamber, egg-laying, filling, camouflaging, and return) were timed for watched (n=10) and control (n=15) turtles. No significant effects on the duration of the seven stages of nesting behavior were found in watched turtles when compared to controls; however, there was a significantly larger variation in the amount of time control turtles spent in each behavior. Clutch success was determined at the end of the season by excavating nests after hatching. Hatched and unhatched eggs were counted for each group. No significant differences were found in the total number of eggs laid nor in the number of hatched eggs in a clutch for watched and control turtles. The large variation in the duration of nesting stages in control turtles suggests that watched turtles nested as quickly as possible while control turtles did not. This might suggest that there is a "minimum" time for each of the nesting stages, and turtles that are being watched may hasten their nesting. The goal of turtle walks is to increase public awareness and increase sea turtle numbers. With no observable effects seen in our study on the hatchling success of watched turtles, turtle walks might prove effective in promoting public awareness and conservation but additional studies should be pursued.

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Exploring temporal and spatial bias in museum collections: An example using the colubrid snake *Sonora semiannulata*

We used Texas specimen records of the colubrid snake *Sonora semiannulata* from seven museum collections to exemplify temporal and spatial biases that influence our understanding of current geographic distributions of native Texas species. Locality data for 1613 specimens were plotted to create a standard dot-distribution map, but dots were color-coded to reflect decade of collection for each specimen. All collections, including the smallest (n = 28), contributed unique county records for the species, emphasizing the importance of maximal collection sampling to refine geographic distribution data. We detected a serious bias in the dates of collections, revealing that the majority of specimens were collected prior to 1980. Standard dot-distribution maps therefore mask the inadequacy of our actual understanding of the current geographic distribution of the species. This is a particularly important consideration in light of extensive land-use changes in Texas in the last 25 years and the impacts they have on the distribution of native fauna. Collection practices through time are not uniform and it is inappropriate to make assumptions of uniformity when assessing historical records for data on past distributions. Although not specifically addressed in our study, this problem is likely to be exacerbated for endangered or threatened species because their conservation status may serve as an increasingly potent disincentive for voucher-based collections. An emerging reliance on museum collections for reconstruction of historical distributions of species must be tempered by an understanding of the limitations and biases associated with such collections. An increased appreciation of temporal bias in museum collections is essential if policy and management decisions are to be based on current knowledge. Long-term monitoring and responsible collection of voucher specimens, combined with a renewed emphasis on adequate field notes, will help to establish a reliable database on changing distributions of Texas fauna for future generations.

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Seasonal variation in habitat use and movement by the Pygmy Short horned lizard (*Phrynosoma douglasii*)

The Pygmy Short horned lizard (*Phrynosoma douglasii*) is endemic to the Pacific Northwest and very little is known about its natural history. We studied the ecology of a population of Pygmy Short horned lizards at the shrub-steppe ecosystem of central Washington from April to October 2004. Microhabitat variables were recorded for each of the 112 horned lizards encountered and the movements of three horned lizards were monitored using radio telemetry. Lizards were associated with sites having a high proportion of bare ground and

minimal grass/shrub cover. Adult activity peaked during June. Lizards showed decreased activity when temperatures were at their extremes. Hatchlings appeared in July and were active at warmer temperatures than adults. Radio telemetry data suggest that this population of horned lizards has minimal movement distances during the summer; the maximum distance observed between all points of relocation for any tracked lizard was less than 30m. Similarly, within their areas of movement, radio tracked horned lizards showed site fidelity for refugia, sleeping, and foraging locations. Analysis of 96 fecal pellets collected from 70 lizards suggests that unlike other horned lizard species, the Pygmy Short horned lizard in Washington is not an ant specialist; juveniles forage almost exclusively on small ants whereas adult diets consist of large ants and higher proportions of coleopteran and hemipteran insects.

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The genus *Retroculus* Eigenmann and Bray: Rediagnosis, monophyly and intrarelationships.

The genus *Retroculus* currently comprises three rheophilic cichlid species with a Central North distribution in South America. *Retroculus* was described by Eigenmann and Bray for *R. boulengeri* later recognized as a junior synonym of *Chromis lapidifera*. Gosse revised the genus *Retroculus*, redescribed *R. lapidifer* and described *R. xinguensis* and *R. septentrionalis*. The genus has been traditionally diagnosed by a peculiar morphology of its epibranchial lobe plus a combination of plesiomorphic characters. In Kullander's phylogenetic hypothesis, the genus is positioned as the basal lineage of the clade formed by South American cichlids. However, the morphology of the species of the genus remains poorly-known. A comparative morphological study of the species of the genus and comparisons with other cichlids, revealed a set of putative synapomorphies for the genus (viz. a presence of a palatovomerine apparatus on the mouth roof; the presence of a hypapophyses on the fourth vertebra; the attachment of the ligament hypoh Laboratory of Fishes, yal-hypobranchial 1 onto anterior-medial spiny process of the first hypobranchial; the second lachrymal plate elongated and constrained to the ventral margin of the first plate and; an slender dentigerous arm of the dentary). We also provide a putative hypothesis of the phylogenetic relationships among species of *Retroculus*. **STOYE GENERAL ICHTHYOLOGY**

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Systematics and phylogeography of members of the *Etheostoma asprigene* species group (Percidae: Subgenus *Oligocephalus*)

A recent allozyme study of the *Etheostoma asprigene* species group demonstrated that *E. swaini* was not a monophyletic species. Populations of *E. swaini* were more

closely related to *E. nuchale* or to some members of the *E. ditrema* complex than to other populations presently recognized as *E. swaini*. The current study is based on complete mitochondrial ND2 sequence sampling across the range of the *E. swaini* complex, including samples from all major drainages. Populations of *E. nuchale* and *E. ditrema* were also sampled, as were geographically representative specimens of *E. asprigene*, *E. caeruleum*, and *E. collettei*; outgroup taxa included representatives of all other percid genera. A monophyletic *Etheostoma asprigene* species group was not recovered based on the previously reported nesting of *E. uniporum* within *E. caeruleum*. *Etheostoma swaini* was also not recovered as monophyletic. Most populations of *E. swaini* fell into two clades, a smaller group including samples from Lake Pontchartrain, Pearl River, St. Louis Bay, and Lower Tombigbee River and a larger group containing primarily samples from Mobile Basin and Eastern Gulf Slope drainages. Three groups were within the larger clade, populations from Choctawhatchee and Apalachicola rivers, Lower Pascagoula River, and a group containing *E. nuchale*, *E. ditrema*, and other *E. swaini* populations. Four clades within this latter group included *E. swaini* from the Alabama and upper Escambia rivers, *E. swaini* from the Black Warrior River plus *E. nuchale*, *E. swaini* from the Upper Tombigbee River and Mississippi Embayment populations in Tennessee, and *E. ditrema*. The placement of some specimens of *E. swaini* in other clades within this analysis may represent introgression with sympatric species of *Oligocephalus*. The current study using DNA sequence data corroborates the allozyme study with regards to some Mobile Basin populations of *E. swaini* being more closely related to *E. nuchale* or *E. ditrema* than to other *E. swaini* populations.

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Molecular systematics of lampreys (Petromyzontiformes)

Although the major lineages of lampreys have been defined for many years through morphological characters, the taxonomic rank of and relationships among these lineages have been contentious. Recent analyses have brought together all previous morphological data in a phylogenetic framework and resulted in a robust hypothesis of relationships among parasitic lamprey species. Unfortunately, non-parasitic species lack many of the adult characters used in these analyses and were excluded. In order to test both this hypothesis of relationships and the hypotheses regarding satellite speciation within the lampreys, we have constructed a dataset based on complete data from the mitochondrial *cyt b* and the third intron of the TAP genes. *Cyt b* supports the monophyly of the Petromyzontiformes and both genes support the monophyly of the northern and southern hemisphere faunas. All families would be monophyletic were it not for the placement of *Mordacia lapicida* which is

recovered in an unresolved trichotomy with *Geotria australis* and the Australian *Mordacia*. Within Petromyzontidae, *Ichthyomyzon* is the only clearly monophyletic multispecific genus, although several subgenera of *Lampetra* are recovered as non-monophyletic due to the placement of single taxa. The cyt *b*-based tree does not support the relationships found among parasitic species based on morphology. There is, however, widespread support for the satellite species hypothesis in both the Petromyzontidae and Mordaciidae. Several interesting biogeographical trends will also be discussed.

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Size matters, but bigger is not always better: females, predators, and male genital evolution

Male genitalia may experience more rapid, divergent evolution than any other animal character – but why? Research during the past several decades has culminated in the view that genital diversification primarily results from postmating sexual selection (e.g. sperm competition, cryptic female choice). However, the potential roles of premating sexual selection (e.g. mate choice) and natural selection have received little attention. We examined the possible importance of these mechanisms by investigating divergence in male genitalia between populations differing in predator regime for two species of livebearing fish (*Gambusia affinis* in Texas, USA and *G. hubbsi* in The Bahamas). Controlling for body size, males exhibited a larger gonopodium (sperm-transfer organ) in predator-free environments than in predatory environments – a trend that persisted across space (multiple populations), time (multiple years), and species. By conducting laboratory experiments with *G. affinis*, we found that premating sexual selection appears to favor larger male genitalia (females exhibited mating preference for males having larger gonopodia), but natural selection in the presence of predatory fishes seems to favor reduced genital size (larger gonopodium size was associated with reduced burst-swimming performance, an important antipredator behavior). While postmating sexual selection is widely presumed to be the most important mechanism driving genital diversification, these findings suggest that alternative mechanisms, particularly for organisms that cannot retract their genitalia, may also prove important. **STOYE ECOLOGY & ETHOLOGY**

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Age and growth of three Hawaiian cardinalfishes

Cardinalfishes (Family Apogonidae) compose an important part of the coral reef-fish community; however, little is known of their life-histories. In this paper we describe otolith microstructure, growth rates and longevity for three cardinalfish

species native to Hawaii. Specimens of *Apogon kallopterus* (to 150 mm in total length), *Apogon maculiferus* (to 140 mm) and *Apogon erythrinus* (a Hawaii endemic; to 58 mm) were collected from the Kaneohe Bay forereef (Oahu, Hawaii) for otolith analyses. Daily formation of otolith rings was validated for both *A. kallopterus* and *A. maculiferus* using alizarine complexone marking (100 mg/l seawater). In comparison to temperate cardinalfishes, all three species are short-lived. *Apogon erythrinus*, the smallest species, has a life-span of around 4 months whereas *A. kallopterus* and *A. maculiferus* may live eight months to a year or more.

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Nuptial signals displayed by female pink-belly wrasse advertise sexual receptivity

In conventional mating systems, females are 'choosy' and not expected to have elaborate mating displays; nevertheless female nuptial signals (FNSs) are observed in a wide variety of taxa. Studies have demonstrated that FNSs indicate female quality and/or reproductive state (e.g. sexual receptivity). Despite the relatively high frequency of occurrence of FNSs in wrasses, few studies have investigated the role of these signals in this diverse fish group. The pink-belly wrasse, *Halichoeres margaritaceus*, occurs on shallow reef flats in the Indo-Pacific, is protogynous (female to male sex change), with cryptic coloration and has a conventional mating system. Courtship lasts 1-2 hours and spawning occurs daily. During courtship, females repeatedly display belly coloration that varies from white to red and have been observed performing conspicuous 'bobbing' behavior. I observed populations of pink-belly wrasse and examined whether females displayed red belly coloration and/or bobbing behavior as advertisements of sexual receptivity. Focal observations of females were carried out one hour prior to spawning. During this period, I recorded belly color rank (0=white, 1=pink, and 2=red), occurrence of bobbing behavior, and frequency of any directed male courtship behavior. Belly color rank for a given female increased significantly 15 minutes prior to spawning. Moreover, males courted females more frequently when females displayed red bellies than pink or white bellies. The occurrence of female bobbing behavior also increased as spawning approached. Results from this study indicate that female pink-belly wrasse display nuptial signals (red belly coloration and bobbing behavior) that effectively advertise sexual receptivity. The hypothesis that such an advertisement could enhance reproductive activity will be explored. **STOYE ECOLOGY & ETHOLOGY**

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Call complexity in northern leopard frogs: Are males advertising beauty or brawn?

The study of communication is of paramount importance for understanding animal interactions and the kinds of information individuals convey to one another. In many species, competition between males and mate choice decisions by females involve highly elaborate morphological, behavioral, or acoustical male displays. My research focuses on a highly exaggerated acoustic trait, the complex advertisement call of a common North American anuran. Northern leopard frogs (*Rana pipiens*) migrate from overwintering sites to temporary ponds in early spring after which they breed for a period of several weeks. Males do not appear to defend territories, but instead partition their time between calling and searching for mates. In contrast to this otherwise simple mating system, northern leopard frogs have a remarkably complex advertisement call. Males use a repertoire of several distinct notes in variable numbers and combinations to generate hundreds of unique calls (perhaps equivalent to the way people put words together to form sentences). Why northern leopard frogs have developed such a complex vocalization system is far from clear. It is not known, for example, if different calls serve different functions. I conducted field and laboratory playback experiments using advertisement calls of varying complexity to test for differential responses by male and female receivers. Males changed their calling behavior in response to call playbacks; some playbacks elicited call matching (responding with the same call type as the playback), others resulted in males switching to aggressive vocalizations, and others caused the males to cease calling altogether. Females exhibited a strong preference for complex calls over simple calls; however, this preference disappeared when call duration was controlled. I will discuss the communicative significance of call complexity in anurans and explore a potential relationship between the development and production of a complex advertisement call repertoire and the proclivity for speciation events in the leopard frog species group. **STORER HERPETOLOGY**

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Ecological correlates to amphibian and reptile diversity among sites in Costa Rica

Questions about species diversity remain central to ecology despite decades of enquiry. By dissecting the components of species richness between and among sites, we may understand how and why communities are different from one place to the next. We examined species diversity components of the amphibians and reptiles from 18 well-inventoried sites in Costa Rica. We quantified alpha (α) diversity - the number of species occurring together at a site (species richness), and beta (β) diversity - the turnover in species due to habitat change. Alpha diversity for both amphibians and reptiles was highest in the lowland rainforests

of the southwest and Caribbean versant of Costa Rica, and lowest in the tropical dry forest of the northwest. Beta diversity was low between nearby sites, but high between the Atlantic and Pacific versants and along the Pacific coast. Interestingly, α -diversity was not explained solely by distance, implying environmental and historical factors may cause differences in species richness at sites, regardless of distance. A cluster analysis grouped similar sites together based on shared species. A canonical correspondence analysis revealed that a temperature-altitude gradient and a sun-rainfall gradient were linked to species richness at sites. Understanding patterns of diversity and how climatic gradients influence species richness is important to developing conservation strategies as we are faced with global climate change and changing land use patterns in Costa Rica.

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Reproductive behavior of Atka Mackerel (*Pleurogrammus monopterygius*) in the Aleutian Archipelago

Atka Mackerel is one of few marine fish species targeted by a commercial trawl fishery and possessing a reproductive strategy involving male parental care. To improve conservation and management, we studied their reproductive behavior using underwater video cameras. Sexually dichromatic Atka mackerel segregate by size and sex during the breeding season. Males aggregate in coastal shelf areas of the Aleutian archipelago in June and establish individual nesting territories. Geomorphic and oceanographic features appear to be important in nesting site selection. Nesting sites are found at depths from 15-140 m and can cover areas exceeding 1 km². Circling and cleaning the nest and aggression towards other fish or male conspecifics are common nesting behaviors among tending males. Reproductively mature females form large schools and are generally on the move during the day. When passing through nesting sites, they stratify vertically above male nesters. At night, females become sedentary and settle to the bottom in areas adjacent or close to nesting sites, and sometimes directly onto nesting sites. Spawning occurs from July to October during daylight hours and increases near dusk. Atka mackerel are polygamous and both sexes can mate with multiple individuals. Males court females by swimming upward towards the female, abruptly turning downward, and then swimming back towards their nest displaying a dorso-ventral caudal tailwag to show the female where to deposit her eggs. Atka mackerel are obligate demersal spawners. Spherical eggs are adhesive, tightly clumped, and are wedged into rocky depressions or crevices. Water temperatures at nesting sites ranged between 3.9° to 11.0°C and egg development takes from 40 to 120 days depending on temperature. Males can guard multiple clutches in different stages of development and may remain on a nesting site for up to 7 months. Egg cannibalism is prevalent in adults of both sexes.

***LAVOUE, SEBASTIEN; MIYA, MASAKI; SAITOH, KENJI;
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Molecular phylogeny of the Clupeiformes (Teleostei) inferred from whole mitogenome sequences

The fishes of the order Clupeiformes (about 400 species, including anchovies, herrings, sardines, menhadens, shads and their relatives) are of prime importance in world fisheries representing almost 25% of the total annual catch. Consequently, they have been the subject of numerous studies within diverse biological disciplines. However, the interrelationships among the main clupeiform lineages are still poorly understood. In this study, we reconstructed the phylogeny of the Clupeiformes using whole mitogenome sequences from 43 species (18 being newly determined for this study). Our taxonomic sampling included at least one species of each clupeiform subfamily and several outgroups chosen among basal teleosts. Unambiguously aligned, concatenated mitogenome sequences (excluding the ND6 gene and control region) were divided into five partitions (1st, 2nd, and 3rd codon positions, tRNA genes, and rRNA genes) and partitioned Bayesian analyses were conducted. The resulting phylogenetic trees were well resolved, with many nodes well supported by the high posterior probabilities. Our results supported the monophylies of the Clupeiformes, Clupeoidei, Engraulidae and Pristigasteridae. *Denticeps clupeoides* was placed in the most basal position within the Clupeiformes. We confirmed that the family Sundaalangidae belongs to the Clupeoidei. Within the family Clupeidae, the subfamily Dussumieriinae is distantly related to the four others (Alosinae, Clupeinae, Dorosomatinae and Pellonulinae). Although altogether, these last four subfamilies formed a monophyletic group, the Alosinae, Clupeinae and Dorosomatinae are not reciprocally monophyletic to each other. Instead, our analysis recovered several well-supported intergeneric clades among the Clupeidae never proposed before, which suggests that the taxonomy at the subfamilial level should be reconsidered. Finally, we advance some general hypotheses about the evolutionary history of the Clupeiformes.

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Phylogeny of the Gonorynchiformes (Teleostei) inferred from whole mitogenome sequences

The order Gonorynchiformes, which includes 31 species assigned to seven genera and four families, exhibits a large variety of anatomical structures,

making difficult the reconstruction of phylogenetic relationships among its representatives. Within the basal teleosts, the Gonorynchiformes belong to the Otocephala where they have been alternatively placed as the sister group of the Otophysi and of the Clupeiformes. In this context, we investigated the phylogeny of the Gonorynchiformes using whole mitogenome sequences from 40 species (six being newly determined for this study). Our taxonomic sampling included at least one species of each gonorynchiform genus and of each other major otocephalan lineage (i.e. Clupeoidei, *Denticeps*, Otophysi and Alepocephaloidei). Unambiguously aligned, concatenated mitogenomic sequences (excluding the ND6 gene and control region) were divided into five partitions (1st, 2nd, and 3rd codon positions, tRNA genes, and rRNA genes) and partitioned Bayesian analyses were conducted. The resulting phylogenetic trees were fully resolved, with most of the nodes well supported by the high posterior probabilities. The mitogenome data supported the monophyly of the Otocephala, Alepocephaloidei, Gonorynchiformes, Otophysi and Clupeiformes. The Gonorynchiformes and the Otophysi formed a sister group, rendering the Ostariophysi monophyletic. Within the Gonorynchiformes, the following original topology was found: (*Gonorynchus* (*Chanos* (*Phractolaemus* (*Cromeria* (*Grasseichthys*(*Kneria*, *Parakneria*)))))). We confirmed that the paedomorphic species *Cromeria nilotica* and *Grasseichthys gabonensis* belong to the family Kneriidae; however, the two species together did not form a monophyletic group.

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Diversity among montane New World microhylids (Anura: Microhylidae)

Represented by 345 species, microhylid frogs are known from all continents except Antarctica, and are characterized by a firmisternal pectoral girdle, palatal ridges, and larvae that normally lack keratinized mouthparts. The 49 species of New World microhylid frogs belong to the Microhylinae and are placed in 18 genera, nine of which are monotypic. Microhylines are predominantly terrestrial (fossorial to semifossorial) denizens of the lowland rainforest. Unlike other microhylines, *Nelsonophryne aequatorialis* occurs at elevations between 2500 and 3615 m in the Andes of Ecuador and its congener, *N. aterrima*, is found at lower elevations between 20 and 1500 m in Middle America and Ecuador. Because of their reclusive habits, microhylids are difficult to find, which may account for our limited knowledge of these anurans. Recent fieldwork in the eastern Andes of central Peru revealed the existence of two new microhylid taxa, neither of which is assignable to any of the existing genera. Morphological and osteological descriptions are provided for the new genus, which represents the first record for Microhylidae in the Andes of Peru, as well as *Nelsonophryne aequatorialis* and *N. aterrima*, with which comparisons are made. Several novel characters that previously have not been used in systematic studies of microhylids are described.

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Cricket frog declines in Ohio: A test of the habitat acidification hypothesis

Recent surveys indicate that Blanchard's cricket frogs (*Acris crepitans blanchardi*) have declined throughout much of the northern portion of their historic range. One of the many mechanisms put forward to explain the synchronous decline of this once common species is habitat acidification. To assess the status of Blanchard's cricket frogs in Ohio, we sampled randomly selected aquatic sites using chorusing surveys on three parallel transects running from the Indiana border to central Ohio (approximately 165 km) in May and June 2004. At each site, we also measured the coverage of aquatic and terrestrial vegetation, pH and alkalinity (a measure of acid neutralizing capacity). While cricket frogs historically occurred throughout the western two-thirds of Ohio, we found extant populations only within about 90 km of the Indiana border. Of 570 sites sampled, 53 (9.3%) were occupied. These results indicate that cricket frogs have disappeared from much of their former range in Ohio. A multiple logistic regression model indicated that increasing terrestrial vegetation surrounding a water body significantly reduced the likelihood of cricket frog presence. There was also a marginally significant positive relationship between cricket frog presence and alkalinity. However, this was not a strong predictor and additional research is necessary to determine if habitat acidification is a likely decline mechanism for cricket frogs.

LEMA, SEAN C.

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Ecophysiology and evolution of behavior and brain in a Death Valley pupfish

Divergent ecological conditions can lead to phenotypic diversification through both genetic selection and phenotypic plasticity. Behavioral phenotypes and their neural and endocrine underpinnings can be particularly sensitive to environmental conditions, even though the ontogenetic origin of variation in these traits has rarely been considered in studies of adaptive evolution. Recently I found variation in brain expression of the neuropeptide hormone vasotocin between two allopatric populations of pupfish (*Cyprinodon nevadensis*) in the wild. Vasotocin regulates hydromineral balance and sociosexual behaviors in fish and amphibians and has previously been shown to modulate aggression in pupfish in the wild. Still, these two pupfish populations have been isolated for less than 4,000 years, so it remained unclear whether the difference in brain vasotocin reflected an evolved change or a plastic response to dissimilar environments. One of these populations lives in a stable habitat of low salinity and constant temperature, while the other population experiences fluctuations in both these parameters. Here I examined whether the ontogenetic response of brain vasotocin to salinity (0.4 ppt or 3 ppt) and temperature (stable or fluctuating) differed between populations. Morphometric analysis of brain vasotocin expression revealed that populations have evolved differences in the plastic response of parvocellular vasotocin neurons to environmental variation.

These neurons have been implicated to regulate social behaviors and stress responses, suggesting that populations may have diverged in these phenotypic attributes. Magnocellular vasotocin neurons which mediate osmoregulatory processes, however, responded to salinity similarly in the two populations. Combined, this plasticity in brain vasotocin expression helps explain the variation in vasotocin phenotypes seen in wild populations. Further, these results provide evidence that plasticity in the vasotocin system can evolve rapidly to ecological conditions in the wild, and illustrate how brain plasticity may generate differences in neuroendocrine phenotypes important to behavioral variation at the population level.

***LENTZ, JENNIFER A.; SWARTH, CHRISTOPHER W.; WILLIAMS, ERNEST H.**

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Home range and habitat preferences of Eastern Box Turtles (*Terrapene carolina carolina*) at Jug Bay Wetlands Sanctuary, Maryland

We examined the home range characteristics of marked eastern box turtles using three analytical methods: minimum convex polygon, bivariate normal, and 90% kernel. Only turtles with five or more sightings were used for this analysis, with a mean of 26 sightings for females (n = 49), 15 for males (n = 47), and 22 for juveniles (n = 4). Home range sizes were affected weakly if at all by the number of sightings. All calculation methods yielded significantly larger mean home ranges for females (12.9 ha) than for males (5.3 ha). Differences between male and female home ranges were greater for the sample of turtles tracked with radio telemetry than for those calculated from random encounters of marked turtles. Overall, females also used more of the available habitats than males. Both males and females were found at higher frequencies in each of the habitats, excluding tidal wetland, than expected based on habitat availability. Females used forests, meadows, *Phragmites* marsh, and scrub-shrub wetland; males used mostly open and dense forests, stream flood plains and meadows; and juveniles used meadow and tidal wetland habitats more than adults. The size and diversity of female home ranges has important conservation implications because, without recognition of this variation, critical nesting and foraging habitats may be overlooked.

LEONARD, NORMAN E.

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Tadpoles of early breeding amphibians are negatively affected by leaf litter from invasive Chinese tallow trees

As wetlands are invaded by Chinese tallow trees (*Triadica sebifera*), native trees are displaced and detrital inputs to amphibian breeding ponds are altered. I used a mesocosm experiment to examine the effect of Chinese tallow leaf litter on the survival to, size at, and time to metamorphosis of amphibian larvae. Fifty 1000-L cattle watering tanks were treated with 1500 g dry weight of one of five leaf litter

treatments: Chinese tallow, laurel oak (*Quercus laurifolia*), water tupelo (*Nyssa aquatica*), slash pine (*Pinus elliottii*), or a 3:1:1:1 mixture. Each tank received 45 tadpoles of *Pseudacris feriarum*, *Bufo terrestris*, and *Hyla cinerea* in sequence according to their natural breeding phonologies. Every *Pseudacris feriarum* and *Bufo terrestris* tadpole exposed to Chinese tallow died prior to metamorphosis. *Hyla cinerea* survival in tanks with tallow only was significantly lower than that observed for all other leaf treatments. *Hyla cinerea* tadpoles from tallow-only and mixed-leaf treatments were larger at metamorphosis and transformed faster than those in tanks with native leaves only. These results suggest that Chinese tallow leaves may negatively affect tadpoles of early breeding frogs and that Chinese tallow invasion may change the structure of amphibian communities in temporary ponds. **STOYE ECOLOGY & ETHOLOGY**

***LE PORT, AGNES; MONTGOMERY, JOHN C.; LAVERY, SHANE**

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Population genetics of short-tailed stingrays, *Dasyatis brevicaudata*

Short-tailed stingrays (*Dasyatis brevicaudata*) have been recorded in New Zealand, Australia and South Africa. They are widely distributed in New Zealand and at times form conspicuous aggregations at some off-shore islands, such as the Poor Knights Islands (NE New Zealand). Despite anecdotal evidence of seasonal migrations, nothing is known about the current levels of connectivity of these widespread populations, or the genetic relatedness among populations. Population genetics were used to investigate the relationship between the Poor Knights Islands aggregation and other New Zealand coastal and island locations. From March 2004 to March 2005, 60 short-tailed stingrays were sampled around New Zealand on SCUBA using a pole-mounted biopsy head. We analyzed geographic patterns of variation in mitochondrial DNA from short-tailed stingrays to investigate genetic relationships within and among locations. Here, we present results of preliminary analyses of short-tailed stingray samples collected from 6 locations around New Zealand. Short-tailed stingray gene flow, its relationship to movement and migration, and implications this has for management and conservation of this species in the Poor Knights Marine Reserve will be addressed. **AES GRUBER**

***LESSA, ROSANGELA; SANTANA, FRANCISCO M.**

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How inefficient has marginal increment analysis (MIA) been for age validation of tropical shark species?

Validating the time of band formation is critical when using hard parts for age estimates, and validation is successful when growth zones are shown to form annually in all age groups. Age and growth were estimated for six tropical sharks *Prionace glauca* (236), *Carcharhinus signatus* (317), *Carcharhinus longimanus*

(110), *Isogomphodon oxyrinchus* (105), *Carcharhinus porosus* (504) and *Rhizoprionodon porosus* (316) collected off Brazil. Marginal Increment analysis (MIA), for validating band deposition, was not conclusive for any species, although differences were found in monthly analyses for *C. signatus*, *C. longimanus* and *P. glauca* using ANOVA. Low readings errors (IAPE) were obtained in all cases (1.74 to 6.0 %). Inconsistency in MIA for all species was attributed to: a) data collection over a too large period, causing variability in ring deposition among years; b) small sample size for any month for any age class, c) Protracted reproductive seasons with birth occurring over a too long period, typical of tropical species. The latter brings about individual MI values of zero and one throughout the analyzed period, leading to monthly mean MI values around 0,5 with low standard deviations when the range of monthly MIA values is considered. The MIA by age groups was useful for elucidating the band formation in juveniles of *P. glauca* and *C. signatus*; however that was not the case for *C. porosus* whose sample was composed of ≈90% of juveniles. Referring to *P. glauca*, although the sample was mostly composed of adults, we failed to demonstrate the time of band deposition for individuals older than 8 years. Summing up, the MIA, which is considered of low resolving power, is specially limited for tropical species due to their biological features. Although MIA is convenient due to the low cost, other methods should be attempted in order all age groups can be validated.

***LESTER, KRISTIE L.; CRAMPTON, WILLIAM G. R.; ALBERT, JAMES S.; LOVEJOY, NATHAN R.**

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Molecular phylogenetics of the weakly electric knifefishes: Biogeography and evolution within the genus *Gymnotus*

Within the otophysan family Gymnotidae, which comprises the weakly electric knifefishes of the genus *Gymnotus*, and the electric eel, *Electrophorus electricus*, recent studies have revealed that species diversity is greater than previously thought. Currently, 30 valid species of *Gymnotus* are recognized in the literature. The diversity of *Gymnotus* species in addition to their widespread geographical distribution, diverse habitat use, and use of weak electrical signaling, make the group well-suited to species-level phylogenetic studies of biogeography and speciation in the Neotropics. A total evidence hypothesis of the phylogenetic relationships within *Gymnotus* is proposed based on molecular sequence data from the mitochondrial cytochrome b and 16S genes, the nuclear RAG-2 gene, and 113 morphological characters. Maximum parsimony trees comprising 17 species and four geographic variants of *Gymnotus* provide partial confirmation of previous findings based on morphological data sets, with the *G. carapo* species group intact. The South American assemblage of *Gymnotus* species is shown to be paraphyletic, with the Central American species (represented by *G. cylindricus*) most closely allied to the *G. carapo* species group. This relationship has important implications for biogeography and the evolution of electric signals within the genus.

***LEWALLEN, ERIC A.; BOHONAK, ANDREW J.**

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The genetic population structure of the leopard shark (*Triakis semifasciata*)

Leopard sharks (*Triakis semifasciata*) are one of several cartilaginous fishes commonly found in the coastal waters of California. Despite their relative abundance, very little is known about the movement, dispersal and population structure of this species. Like other k-selected predators, this species is susceptible to population depletion. By learning more about the genetic population structure of leopard sharks, it may be possible to make better-informed management decisions regarding this ecologically significant predator. Cartilaginous fishes are slowly-evolving and have extraordinarily large amounts of genomic DNA. The first question addressed in this study is: What is the genetic population structure of leopard sharks? Answers provided by this investigation may reveal relative dispersal capabilities and general movement patterns. The second question to be addressed in this study is: What molecular markers can be used to assess population structure? Preliminary research has shown that inter simple sequence repeats (ISSRs) are useful for screening large amounts of genetic material for polymorphic loci within a species. This technique may prove to be broadly applicable and useful for other population genetic studies involving little-studied vertebrate species.

LI, BLAISE; *LECOINTRE, GUILLAUME

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Shaking the acanthomorph tree

Acanthomorph fishes represent one third of the extant vertebrates. The idea that large-scale phylogenetic interrelationships of most vertebrates are known is widely spread. This idea is far too simple. Even forty years after the spread of Hennig's ideas, relationships of some large groups of vertebrates have never been really tested by computerized phylogenetic methods. For some groups like acanthomorph teleosts, interrelationships have been investigated from anatomical characters, however without a real matrix. As a result, most of acanthomorph suborders have never been gathered into a single matrix before the recent molecular data. This partly explains why the new acanthomorph tree seems so surprising. Last but not the least, the new placental mammalian tree shows that even when the diversity of a group has been grasped into a single matrix, homoplasy in anatomical character is such that they roughly fit to the old anatomical cladogram as well as to the new molecular one. However, these levels of homoplasy cannot be generalized. Starting from what we called "the acanthomorph bush", we will summarize a number of clades new for science and considered as reliable. The criterion of reliability is based on repeated occurrence of the clade from independent data (each of our nuclear genes as well as trees from other data and teams).

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Towards a reliability index for clades: An application on acanthomorph teleosts

In phylogenetics, the assessment of the quality of results has three main components: robustness, sensitivity and reliability. Robustness evaluates the stability of the results when the data are subject to perturbation, as is the case when one calculates bootstrap supports. Sensitivity evaluates the stability of the results when there are variations in the tree reconstruction method (or other kind of analytical variations). Here we address the case of reliability, which is the credit one gives to a statement at a given time. It may take into account several results, each of which has its own robustnesses and sensitivities. But when it comes to measure it in a standardizable way, it is better to deal only with data analyzed the same way. We propose to measure the reliability of clades by indexes based on the repetition of their occurrence in analyses of independent data sets. In fact, it consists in approaching the degree of "realness" of results (clades) by their degree of corroboration. Such a reliability index has to take into account the maximum number of instances of the clade across independent analyses, but also other complex elements. These are contradiction among clades, and the probability of a clade to occur in a case where there would be no signal in the data. The calculation of such an index has been implemented in a computer program. It has been tested with a data set of several genes for acanthomorph teleosts.

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Conservation genetics of the Plains Topminnow (*Fundulus sciadicus*)

The plains topminnow, *Fundulus sciadicus*, is a freshwater killifish native to the Great Plains. The primary area of distribution is in Nebraska while a second set of allopatric populations occurs in central and southwestern Missouri. The disjunct range of this species has been attributed to the effects of the Kansan glaciation but can also be explained by recent habitat change and fragmentation. Recent reports suggest that populations of the plains topminnow are declining in both Nebraska and Missouri. Here, we are assessing range-wide mtDNA and microsatellite diversity to test hypotheses of current and historical forces that have shaped the distribution and evolution of the species. We are also estimating effective population size and population growth/decline rates in each of the three disjunct areas. Initially, we sampled 32 locations with historical records in Nebraska but were only able to collect *F. sciadicus* at 10 of these sites. Preliminary mtDNA sequence data indicates extremely low genetic variability in Nebraska. Indeed, the entire mtDNA control region (940bp), one of the most rapidly evolving genetic markers, is identical in 74 of 79 individuals examined. Two single point mutations occur in the remaining five individuals. Such extreme homogeneity is surprising given that samples are separated by as many as 1300 river kilometers and accentuates the need for further investigation. We are

currently screening 20 microsatellite markers from *F. heteroclitus* for efficacy in *F. sciadicus*. In addition, we are developing our own suite of microsatellite markers from *F. sciadicus*. These markers will complement the mtDNA data set and enable a more precise estimation of population parameters in the species.

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Phylogenetic relationships among families of Clupeiformes based on mitochondrial and nuclear gene sequences

Clupeiformes are worldwide distributed, inhabiting primarily marine and estuarine waters, but are also present in strictly freshwater habitats. Currently, about 380 species of clupeiform fishes have been described and placed in 5 families. The taxonomy of clupeiform fishes has been extensively studied but many phylogenetic questions are still unresolved. For example, the interrelationships among the families Pristigasteridae, Engraulidae and Clupeidae are still controversial. No molecular data have been published to study these questions. In this study, both mitochondrial and nuclear gene markers are used to address the unresolved relationship among families in Clupeiformes. The mitochondrial genes used are those encoding for ribosomal 12S and 16S subunits. The nuclear genes include recombination-activating protein 1 (RAG1) gene and recombination-activating protein 2 (RAG2) gene. Phylogenetic trees based on multiple data partitions are constructed by using parsimony, maximum likelihood, and Bayesian criteria. New and current hypothesis for phylogenies of Clupeiformes are tested explicitly. The long-term goal of this project is to obtain a phylogenetic tree of Clupeiformes with robust support from multiple molecular and morphological data. It will provide useful knowledge to studies of taxonomy, historical biogeography, evolution, and comparative ecology of Clupeiformes.

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Dispersal and potential kin discrimination in red-backed salamanders, *Plethodon cinereus*

Little is known about the dispersal of amphibians with direct development, including information about the dispersal or lack thereof in juveniles. Laboratory tests have demonstrated that males of *Plethodon cinereus* are less aggressive towards familiar juveniles. Because aggressiveness and cannibalism occur in *P. cinereus*, if adults permit offspring to persist in territories defended from other adults, this would confer an advantage to offspring. In order to quantify juvenile movements and the relations of juveniles to nearby adults, two 10 m x 10 m plots have been gridded for a long-term mark/recapture study to delineate territories and movements of adults and juveniles of *P. cinereus* at Mountain Lake Biological Station in the Appalachian Mountains of Virginia. *P. cinereus* are marked and recaptured during nocturnal surveys and cover object searches. Parental analysis

using 5 microsatellite DNA primer pairs will evaluate parentage of juveniles. Juvenile persistence in parental territories of *P. cinereus* that are defended against other conspecifics would support a hypothesis of kin discrimination. The alternate hypothesis is that juveniles disperse and data will evaluate the extent of dispersal.

LIGON, DAY B.

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Conservation implications of incubation temperature for alligator snapping turtles (*Macrochelys temminckii*)

Alligator snapping turtle (*Macrochelys temminckii*) populations have declined markedly in recent decades, partly due to anthropogenic forces such as commercial harvesting and impoundment of rivers throughout the southeastern United States. In response, a captive propagation effort has been initiated in Oklahoma, with the goal of producing healthy juvenile turtles that can be released into rivers where the species has disappeared. Several traits that are influenced by incubation temperature (Tinc) can impact the success of such "head start" initiatives; perhaps most profound of these is sex. In addition, traits such as size, growth, activity levels, and mortality, all potential correlates of fitness, may be influenced by Tinc. Here, I present results from a study of physiological effects of Tinc on early development in alligator snapping turtles. Eggs were obtained from nests within 48 h of deposition and incubated under controlled conditions at three constant temperatures (26.5, 28.5, 30.5° C). Resting metabolic rate (RMR; oxygen consumption) of individual eggs was measured weekly throughout incubation. After hatching, RMR was measured at each of the three Tinc to determine the degree to which acclimation resulted in metabolic compensation. Finally, growth was monitored for 10 weeks post-hatching. As expected, incubation duration was inversely proportional to Tinc. Turtles incubated at 30.5° C consumed less oxygen during development than those from lower temperatures, and were smaller at hatching. Similarly, the magnitude and timing of the peak RMR exhibited by embryos correlated negatively with incubation temperature. Among hatchlings, there was no indication of metabolic compensation to their respective incubation temperatures. Tinc effects on growth varied with the water temperature to which hatchlings were exposed. These results indicate that moderate temperatures during embryonic development may optimize many physiological performance traits, and that close attention to Tinc may enhance the success of turtle head start programs. **STOYE PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY**

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Interspecific variation in physiological response to incubation temperature among four sympatric turtle species

Turtles worldwide have experienced population declines in recent decades, primarily due to habitat degradation and human consumption. Several national and international conservation organizations have responded by purchasing

land for preservation, and by supporting efforts to propagate critically endangered species in captivity for future reintroduction. These efforts must contend with several challenges, such as maintaining genetic diversity and ensuring production of an appropriate sex ratio, particularly in species with temperature-dependent sex determination. Before these factors can be considered, however, the steps necessary to produce hatchlings that are physiologically vigorous, and thus likely to survive after repatriation, must be determined. Appropriate incubation protocols are well-documented for some species; however, the degree to which they can be generalized is unclear. Here, I compare physiological responses of four sympatric species to similar incubation conditions. Alligator snapping turtle (AST), red-eared slider turtle (RES), spiny soft shell turtle (SST), and three-toed box turtle (TBT) eggs were collected from nests or following oxytocin administration to gravid females. The eggs were incubated on a 1:1 (by mass) vermiculite:water mixture, and individual clutches were evenly distributed among three incubators maintained at 26.5, 28.5, and 30.5°C. After hatching, metabolic rates (O₂ consumption) were measured at each of the three incubation temperatures (T_{inc}) to determine the capacity for metabolic compensation. Finally, post-hatching growth was monitored for 10 weeks. AST and RES hatchling mass was affected by T_{inc}. RES and SST exhibited moderate metabolic compensation, whereas AST and TBT exhibited none. Only AST growth was influenced by incubation temperature, and both RES and AST exhibited high growth rates. In contrast, TBT and SST ate little and showed little to no growth for the first 10 weeks after hatching, suggesting that hibernation in the nest or post-emergence may be hard-wired for these species. These results suggest that caution should be exercised when extrapolating husbandry protocols, even to species that inhabit similar habitats. **STORER HERPETOLOGY**

***LILLYWHITE, HARVEY B.; ZAIDAN, FREDERIC III; SHEEHY, COLEMAN M. III**

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Marine scavenging by insular cottonmouth snakes: Evolutionary scenario for invasion of the sea

Despite controversy concerning marine *vs.* terrestrial origins of snakes, the majority of some 3000 species reside in subterranean, terrestrial, or freshwater habitats. Fewer than 2.5% of total snake species, representing four major clades, live successfully in marine environments, and only a few other species inhabit brackish and marginally marine habitats. Presumably, invasion of the sea by terrestrial taxa is difficult, owing to physiological, behavioral, and biotic challenges. We report the first evidence for marine scavenging and deliberate plant consumption in a terrestrial pit viper, which represents an important and characteristically terrestrial group of vertebrates. We studied insular cottonmouth snakes, *Agkistrodon piscivorus conanti*, residing at bird rookeries on Florida Gulf Coast islands where adults feed largely or exclusively on fishes that are dropped or regurgitated by colonial nesting birds. However, occasional dead fish that might be washed upon the shore by tidal waters offer another potential source of food that is sometimes utilized by these snakes. Therefore, utilization of

marine prey occurs in two ways: first, dependent utilization of marine fishes that are dropped by colonial nesting birds, and, less commonly, utilization of marine fishes that might appear as carrion at the shoreface. Additionally, we show that individual snakes occasionally scavenge at the shoreline where they ingest marine debris, presumably due to presence or odors of dead fish. In the laboratory we demonstrate that snakes will ingest marine algae or other marine plants if they have previously contacted dead fish. We do not suggest that these insular cottonmouths are becoming marine. However, the ecology and behavior of this population suggests an evolutionary scenario that is requisite for successful transition of vertebrates from terrestrial to marine existence.

***LINDEMAN, KEN; APPELDOORN, RICHARD; CLARO, RODOLFO; CAMARENA, TOMAS**

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Marine protected areas in Cuba, Mexico, and Florida: Comparative research and management trends

A series of MPA networks at multiple spatial scales are coalescing in the northwest Caribbean. In part by opportunism, but increasingly by design, these MPAs may help ensure more sustainable local and regional fisheries. However, critical components are still under development and opportunities to fail are abundant. Over 10 existing and pending MPAs from Cuba, Mexico, and Florida were examined as fishery and habitat management tools using diverse indicators. Analyses of fishery effects are often confounded since many MPAs have erratic enforcement and the controls necessary for evaluation are therefore unreliable. Without well-justified and enforced reserves (no-take areas), many MPAs exist administratively but provide little resource protection. Enforced protection of spawning aggregations, important for network connectivity, can be a significant benefit, particularly when migrations are also protected outside of the MPA. Cuba is building the largest national MPA network in the Caribbean using a process that includes ecoregional characterization of shelf habitats, spawning site identification, MARXAN decision support modeling, and integrated agency implementation as new MPAs receive administrative approval. Networks of MPAs that contain many reserve areas now exist in both Mesoamerica and southeast Florida. Although not originally designed in an integrated trans-national fashion, these reserves have potential to protect key attributes of local population structure both within and between regions. Though habitats and fisheries are biologically co-dependent in all regions, legal differences often confound their management. Some MPA designations provide for habitat protection in addition to fishery regulations. Attributes that are common to success in all initiatives include: 1) early and consistent interactions with local fishing organizations; 2) comprehensive management plans; 3) well-designed research that evaluates key reserve attributes; and 4) consistent enforcement. MPA effectiveness is highly constrained in the absence of any of these attributes.

***LINER, ANNA E.; CASTLEBERRY, STEVEN B.; SMITH, LORA L.; GIBBONS, J. WHITFIELD**

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Wetland predictors of amphibian diversity and distribution in southwest Georgia

Isolated wetlands are a dominant part of the landscape of the Coastal Plain of the southeastern United States and provide breeding or primary habitat for 36 southeastern amphibian species. However, isolated wetlands can vary in a number of factors that may affect the ability of species to successfully colonize or breed within them. I examined the relationship between wetland variables and the distribution of amphibian species in 29 relatively undisturbed isolated wetlands in Baker County, Georgia, USA. Wetlands were sampled for amphibians in the winter, spring, and summer using aquatic traps, dipnetting, PVC pipe refugia, and automated frog call recording devices (frogloggers). Species presence will be compared with wetland hydroperiod data, water chemistry variables, the presence of fish and other predators, and GIS landcover data. The resulting patterns in species distributions in relation to wetland variables will be discussed. Understanding the factors that affect the distribution of amphibians among unaltered wetlands can serve as a basis for restoration and monitoring efforts in disturbed wetlands.

***LIPS, K. R.; BREM, F.; BRENES, R.; REEVE, J. D.; ALFORD, R. A.; VOYLES, J.; CAREY, C.; COLLINS, J. P.**

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Infectious disease and global biodiversity loss: Pathogens and enigmatic amphibian extinctions

We report the first unambiguous link between the arrival of a chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), into a naïve amphibian community at El Copé, Panama, and subsequent mass mortality and loss of amphibian biodiversity. *Bd* was absent in 1,566 amphibian samples collected over 4 years, but quickly increased in prevalence (10-50%) following the first detection in September 2004. The first dead amphibian was found on October 4, 2004 and subsequent mortality was high (>3 dead located/d) through January when most populations had declined. We found 346 dead anurans and 5 dead salamanders between October 2004 and February 2005 on terrestrial and riparian transects. Dead frogs were from 38 species (57% of the amphibian fauna) and all 7 families found at El Copé. All but 3 of the 249 dead amphibians examined were infected with *Bd*. Amphibian density and species richness increased during 6 years of surveys until September 2004 when both declined abruptly in diurnal and nocturnal riparian amphibian communities 1 mo before we first detected *Bd*.

Density and species richness of terrestrial transects did not decline significantly although numbers were reduced. Several amphibian species have not been seen for several months, and abundance continues to decline. We found no evidence that ranavirus, chemical contamination, climatic anomalies, exotic species, land use change, or overharvesting contributed to mortality or declines. Our data support chytridiomycosis as the cause of mortality and subsequent population declines, and support a model in which *Bd* has spread southward through Central America at 30 km/yr. We propose *Bd*-induced chytridiomycosis as the primary cause of other enigmatic amphibian declines worldwide. *Bd*'s lethality and broad host range make this emerging pathogen a threat to an entire vertebrate class; under these circumstances it is no longer correct to speak of Global Amphibian Declines, but more appropriately of Global Amphibian Extinctions.

***LIPPS, GREGORY J.; ROOT, KAREN V.**

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A framework for predicting the occurrence of rare amphibians: Case study of the Green Salamander

The worldwide decline of amphibian populations has been well documented. Understanding and mitigating these declines has been greatly hampered by the lack of baseline data of amphibian occurrence and abundance. Traditional field surveys which rely on expert opinion to identify areas of potential habitat can be inefficient and unsystematic. The green salamander (*Aneides aeneus*) is a cryptic habitat specialist, spending most of its life in crevices of rock cliffs and outcrops within forested areas. This research incorporates the use of species occurrence data, Geographic Information Systems (GIS), and field surveys to develop a model for predicting the occurrence of this rare and endangered salamander across its range in Ohio. Environmental data derived from GIS layers was used to characterize six habitat variables (elevation, slope, bedrock, percent canopy cover, distance to water, and mean annual temperature) at all known green salamander locations in Ohio. An inductive habitat suitability model developed from this data was used to produce GIS maps of predicted occurrence in three southern Ohio counties. In addition to locating unknown populations, the relative importance of each variable in the model was examined by surveying areas predicted to be the most suitable for all but one of the habitat variables. Field surveys during 2004 conducted to validate the model led to the discovery of four new localities for this endangered salamander in areas with the most suitable habitat, as predicted by the model. One additional population was discovered in an area incorrectly categorized (due to the spatial resolution of the data) as having inadequate slope for the green salamander. This study provides an easily applied framework for efficiently predicting and locating rare organisms, as well as for testing assumptions and parameters of habitat suitability models. **SSAR SEIBERT CONSERVATION**

***LITZGUS, JACQUELINE D.; HOPKINS, WILLIAM A.; CONGDON, JUSTIN D.; MOUSSEAU, TIMOTHY A.**

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Bioenergetics of a declining freshwater turtle (*Clemmys guttata*)

Ecological energy budgets describe patterns of allocation of energy by individuals to the competing functions of maintenance and production. We combined laboratory and field data to examine the two largest components of the maintenance portion of the energy budget (basic maintenance and activity) for spotted turtles (*Clemmys guttata*), a declining species. Because the spotted turtle is semi-aquatic, we could not use the doubly-labeled water method to estimate field activity energy expenditures. We used standard metabolic rate (SMR) data collected in the lab using respirometry, and body temperature data collected from turtles outfitted with temperature-sensitive radio transmitters in the wild over two years to estimate seasonal basic maintenance and field activity energy expenditures. Behaviours observed in the field were ranked and combined with data from respirometry trials to estimate field scope, an index of activity. Basic maintenance energy costs were multiplied by field scope to estimate field activity energy expenditures. Activity, basic maintenance energy expenditures, and field activity energy expenditures varied seasonally. As expected, activity and energetic costs were lowest in winter. Activity levels were generally highest in spring and fall; however, daily basic maintenance and field activity costs were highest in summer. Our first order approximation of basic maintenance and field activity energy expenditures in free-living spotted turtles is an important step towards understanding the energy requirements of this declining species.

LOBEL, LISA K.

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Field studies evaluation developmental and reproductive effects of chemical exposure in the coral reef fish, *Abudefduf sordidus* (Pomacentridae)

Assessing chemical impacts in coral reef environments has been difficult due to a lack of monitoring criteria as well as appropriate benchmarks for risk assessment. Knowledge of chemical concentrations at which adverse effects are observed in the field is limited since many reef monitoring programs are designed to quantify ecological responses but not specific stressors. Effects of PCB contamination on development and reproduction of the reef fish, *Abudefduf sordidus* were assessed by comparing developmental abnormalities, larval morphology, and temporal spawning patterns between PCB contaminated and uncontaminated areas within Johnston Atoll, Central Pacific Ocean. In order to determine the independence of samples collected from multiple clutches within nests, microsatellite loci were used to assess parentage and reproductive behavior. A significant positive residue-effect relationship was found between embryo abnormalities and PCB concentrations in adult tissues. Increased

embryonic abnormalities occurred at PCB contaminated sites. Differences were found in the relationship between larval length and yolk sac area at hatching. While larger larvae from all sites had similar yolk reserves at hatching, smaller larvae from PCB sites had smaller yolk reserves compared to those from reference sites. Variable spawning patterns were observed between *A. sordidus* colonies at PCB contaminated and uncontaminated sites, but variation was related to colony size not contamination. Samples from multiple clutches within nests were independent since genetic evidence suggested that clutches were spawned by different females. These results provide new monitoring criteria for reef environments contaminated with PCBs as well as valuable life history information needed for future biological monitoring efforts. **STOYE**
PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY

***LOBEL, PHILLIP S.; LOBEL, LISA K.**

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Movement patterns of the grey reef shark, *Carcharhinus amblyrhynchos*, at Johnston Atoll and Palau.

Acoustic telemetry was used to study movement patterns of the grey reef shark, *Carcharhinus amblyrhynchos* at two coral reef locations in the Pacific. The focus of the Johnston Atoll (JA) study was to examine contaminant uptake in a top predator. The focus of the study in Palau was to identify shark residency patterns and to explore implications relative to conservation issues, particularly the domain needed for a marine protected area aimed at reef shark protection. At the Palau site, Blue Corner, the key question was whether the sharks seen by divers on a daily basis are the same ones over a long time. If so, we wanted to determine how large a domain was necessary to be delineated as the marine protected area (MPA) in order to best protect those sharks. Individual *C. amblyrhynchos* were outfitted with acoustic tags to determine their frequency of return to certain key reef sites where underwater acoustic loggers were deployed. At Johnston Atoll, the sites of concern were where sediment and reef fish contamination (e.g. PCBs, dioxins, heavy metals) were greatest. In Palau, the key site is Blue Corner, one of the main destination scuba dive locations for the ecotourism industry. The question for sharks at both locations was: how long do individuals remain at or routinely visit a particular reef location? At JA, we found higher than expected levels of contaminants in the shark tissues indicating that individuals may have been more site specific/frequent than previously anticipated. At both locations, we found that individual sharks were much more site specific than expected. Overall, our study objective is to learn more about the natural history of *C. amblyrhynchos* on Pacific reefs and to apply this knowledge to the conservation of the species.

***LOCASCIO, JAMES V.; MANN, DAVID A.**

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Diel and seasonal variability in black drum (*Pogonias cromis*) sound production

Diel and seasonal variability in sound production of black drum (*Pogonias cromis*) associated with courtship and spawning, was investigated in residential canals of southwest Florida during 2004-2005. Acoustic data were collected using the Long Term Acoustic Recording System programmed to record ten seconds of sound every ten minutes within the frequency range of 0-3333 Hz. Recorded calls were validated as black drum by comparison to published descriptions of sounds produced by this species. Black drum produce low frequency, pulsed sounds with the majority of acoustic energy concentrated below 500Hz. A strong diel pattern of sound production was evident where calling began in the late afternoon or early evening and ended by early morning. Relative sound pressure levels recorded during the study period are in agreement with the spawning season reported in the literature. An association between patterns of sound production and lunar phase was also investigated.

LOCASCIO, JAMES V.; MANN, DAVID A.

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Love in the eye of the storm: Hurricane Charley did not impact fish chorusing

Hurricane Charley, a category four hurricane, passed through Charlotte Harbor, Florida directly over an autonomous underwater acoustic datalogger used to record fish sound production associated with courtship and spawning. Acoustic recordings made on days immediately prior to, during, and after the storm provided unprecedented documentation of the hurricane's passage and its effect on fish spawning behavior. The hurricane did not inhibit nightly chorusing events of spawning fishes. Sound levels on the night of and three days after the hurricane were higher and lasted longer than any of the nine days recorded prior to the hurricane.

***LOEFER, JOSHUA K.; SEDBERRY, GEORGE R.**

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Satellite pop-up tagging provides a first look into the diel migration patterns of the night shark, *Carcharhinus signatus*.

Five night sharks (*Carcharhinus signatus*) caught off the coast of South Carolina were fitted with satellite pop-up tags on 26 June 2003. One specimen suffered from immediate post-release mortality, but the other four carried tags for 90 to 120 days. The tags were programmed to record hourly depth, temperature and light readings throughout the deployment interval. Data recovered from the tags indicated all specimens made a net northeastward movement of 195 to 575 km

during the deployment. Analysis of depth and temperature data demonstrated a consistent pattern of diel vertical migration in all specimens. This vertical migration pattern bore a strong resemblance to that observed for swordfish (*Xiphias gladius*) in the same region, though swordfish rose to shallower waters at night and dove deeper during the day. Night sharks spent daylight hours in approximately 260 to 380 m of water in mean temperatures of 10.0 to 10.6 C. Nocturnal behavior was marked by an ascent to shallower waters of 60 to 90 m and approximately 20.0 to 24.5 C. This is believed to be the first electronic tagging study of any type on this species.

LONGENECKER, KEN

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Ichthyology in the service of marine mammal conservation: Foraging of the endangered Hawaiian Monk Seal inferred through high-resolution dietary analysis

Population size of the endangered Hawaiian monk seal, *Monachus schauinslandi*, is apparently food limited and the assumption that seals forage in shallow coral reef habitats may need revision. I am combining high-resolution dietary analysis with ecological information on prey fishes to improve understanding of monk seal foraging behavior and food requirements. Prey hard parts are identified by comparison to a collection of Hawaiian fish skeletons. Diagnostic structures from this collection are being photographed and incorporated into an image management program to aid foraging ecologists in the efficient, species-level identification of fish remains. This approach provides, on average, new or more-detailed information about Hawaiian monk seal foraging in one of every three samples examined. Thirty-six regurgitate samples (spews) yielded 3 fish families never before reported from monk seal diets, including morid cods typically found at sub-photic depths. Nearly 10% of the spews examined contained morid cods. Less common, but also indicative of deep-water foraging were the holocentrid, *Pristilepis oligolepis*, the diodontid, *Chilomycterus reticulatus*, and a tentatively identified cynoglossid. More common prey were *Ariosoma marginatum* (Congridae), *Iniistius* (Labridae), and *Torquigener* (Tetraodontidae), all of which live in or over open sand. Combined, these results suggest Hawaiian monk seal foraging habitat includes deeper water and sand bottoms.

LOPEZ, J. ANDRES

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Synthesizing phylogenetic information from disparate sources of data: progress in basal euteleost relationships (?)

Disagreement over methods for combining phylogenetic information derived from morphology and molecules is still the cause of intense debate decades since the development of the technology that permits fast collection of genetic data and despite continued advances in phylogenetic theory. The debate is generally framed by the two opposing perspectives commonly known as total evidence and taxonomic congruence. By necessity, arguments for and against these

competing approaches are most often made by means of model simulations of data or first-principles philosophical claims. The importance of improving the understanding of the philosophical and performance characteristics of all methods of scientific inquiry cannot be undervalued. However, it is often the case that real situations that call for synthesizing phylogenetic hypotheses from molecular and morphological data sets present particular challenges not easily placed in the context of the prevailing views in this debate. The nature and impact of these challenges are illustrated through a detailed examination of the morphological and molecular evidence that has been offered in support of alternative hypothesis of relationships among basal euteleost lineages. I suggest that to promote advancement in phylogenetic synthesis it will be useful to make this type of analysis an essential component of published work.

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The Panmixia Paradigm of eastern Pacific olive ridley turtles revised: consequences for their conservation and evolutionary biology

Previous studies of the olive ridley *Lepidochelys olivacea* population structure in the tropical eastern Pacific have suggested the existence of a single panmictic population ranging from Costa Rica to Mexico. This information has been used to design specific management measures aimed to conserve main nesting beaches in Mexico. However, little has been known about olive ridleys in the Baja California peninsula, their northernmost reproductive limit, where recent observations have shown differences in nesting female behavior and size of hatchlings relative to other continental rookeries. We used sequences of mitochondrial DNA control region of 137 turtles from five continental and four peninsular nesting sites to determine whether such differences are related to a genetic distinction of Baja California olive ridleys or to phenotypic plasticity associated to the extreme environmental nesting conditions typical of this region. We found that genetic diversity in peninsular turtles was significantly smaller than in continental nesting colonies. Analysis of molecular variance revealed that a significant molecular fixation index ($F_{st} = 0.048$, $p = 0.006$) resulted only with the inclusion of peninsular samples. Our results suggest that the observed phenotypic variation may be associated to genetic differentiation and reproductive isolation; support the recent colonization of the eastern Pacific by *Lepidochelys*; reveal genetic signatures of historical expansion and colonization events; and significantly challenge the notion of a single genetic and conservation unit of olive ridleys in the eastern Pacific, warranting the critical need to revise the conservation measures of olive ridleys in Mexico to grant peninsular beaches special attention.

LOPEZ-FERNANDEZ, HERNAN

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**A preliminary study of life history and mouthbrooding evolution in
Neotropical geophagine cichlids**

Little is known about evolution of life history parameters in Neotropical cichlids. I present a preliminary comparative study of several life history variables in South American cichlids in the subfamily Geophaginae. Life history variables potentially associated with the evolution of mouthbrooding are analyzed in a phylogenetic context for most genera of geophagines. In particular, correlations between body-size and variables related to mouthbrooding are explored. Some evidence suggests the existence of trade-offs among life history parameters in association with parallel evolution of mouthbrooding.

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**Preliminary survey of fish assemblages of the Northwestern Atlantic
Ocean along latitudinal and depth gradients**

A preliminary survey of nearshore and offshore fishes along the Atlantic coast was conducted during winter (17 January - 28 January) in order to explore patterns of diversity and community structure along gradients of depth and latitude. These patterns are not well-known for the inshore and offshore fish assemblages in the northwestern Atlantic Ocean. A total of eight inshore and offshore sites were sampled from the Delaware Bay to South Carolina, most with multiple tows of an 11m Yankee Otter trawl for 30 minutes. Average offshore site depth (98m) was more than double nearshore site depth (32m). Species abundance and richness were usually higher at nearshore sites, averaging 266 individuals/site and 13 species/site, more than half of those collected at offshore sites. The most abundant species were scup (*Stenotmus chrysops*) and spiny dogfish (*Squalus acanthias*). A different morphotype of scup with a long, filamentous extension of the first dorsal spines was collected near South Carolina. More species were collected near South Carolina than northern sites regardless of depth. Rarefaction and multivariate methods will be used to better evaluate how diversity and assemblage structure differ by latitude and depth.

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**Seasonal and human disturbances affect fish assemblages from coastal
bays of Maryland**

Spatial and temporal differences in fish assemblage structure were investigated for the coastal bays of Maryland (U.S.A.). Dredging and urbanization near the

Ocean City Inlet (OCI) of Maryland resulted in a gradient of spatial differences in disturbance throughout the coastal bays. We used multivariate methods to investigate differences in assemblage structure for ray-finned fishes across 44 consecutive months (1996-1999) and three *a priori* defined levels of human disturbance (high = within 8 km radius of OCI; moderate = outside 8 km radius of OCI; low = reference sites sampled by Maryland Department of Natural Resources). Using a non-metric multidimensional scaling (NMS) of data collected in 1996 and 1997, we found that assemblages were structured along temporal and spatial gradients of season and disturbance, respectively. The predictive mode of NMS was used to score sites sampled in 1998 and 1999 along these gradients. The model more successfully predicted scores for season, but not for disturbance. Multi-response permutation procedures, similar to a discriminant functions analysis, suggested strong differences between seasons (summer = July - September; non-summer = October - June) and weaker differences among disturbance levels. None-the-less, least disturbed sites often harbored habitat specialists (e.g., green goby, *Microgobius thalassinus*) that were not collected elsewhere. After 4 years of intensively sampling coastal fish assemblages, we conclude that both spatial differences in human disturbance and temporal differences in season influenced assemblage composition, although the latter were much more pronounced for this system.

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Status of *Atelopus varius* within a biological corridor in South-central Pacific Costa Rica

Atelopus varius is a critically endangered species that was historically widespread and abundant in Costa Rica until dramatic population declines occurred in the late 1980's, and the last *A. varius* in Costa Rica was seen in 1996. This species was previously known from several widely dispersed localities along the South-central Pacific coast at elevations from 50 m to 550 m. Since the last known field observation of *A. varius* in Costa Rica, there have been few extensive studies to adequately assess its status on a regional scale. We reviewed published and unpublished historical accounts of *A. varius* from the Pacific Coast of Costa Rica, and summarize recent intensive field survey data from the region. As part of a long-term amphibian monitoring study of this region an extensive survey program was begun in 1999 to survey the coastal mountain range of South-central Costa Rica from the Rio Terraba to the Rio Savegre river basin. Extensive surveys conducted between 1999 and 2004 (28 consecutive months; 2,137 field hours; 40 streams) found no individuals at historic locations, and no new populations were located. This is one of the first regional evaluations of *A. varius* in Costa Rica to assess the species persistence and our results indicate that this species is facing extirpation in the South-central Pacific mountains. The recent discovery of an extant population north of the study area suggests the possibility that *A. varius* is not yet extinct in Costa Rica, but further regional surveys are necessary.

***LOWE, CHRISTOPHER G.; FRIEDLANDER, ALAN; BEETS, JIM; CASELLE, JENNIFER; PAPASTAMATIOU, YANNIS P.**

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Movements of blacktip reef sharks (*Carcharhinus melanopterus*) in lagoons at Palmyra Atoll

Palmyra is a remote, pristine, undeveloped atoll where minimal human activity and fishing has occurred over the last 60 years. Site fidelity and movement patterns of blacktip reef sharks were determined using acoustic telemetry monitoring (VR2) in lagoons at Palmyra. Fifteen adult sharks (mean TL 110 ± 11 cm) were monitored for up to 411 days (mean 233 ± 144 days). Four of the 15 sharks were only detected for up to 75 days. Sharks were found to move through all three major lagoons at Palmyra, moving at least 6 km between monitors. The longer sharks were detected the more likely they were observed to move to different lagoons. Several short-term, fine-scale acoustic tracks indicated that sharks move along reef edges during low tide, but move up onto the reef flats at high tide. This behavior corresponds with observed movement patterns of bonefish and other teleost prey, which use the reef flats to forage during high tide.

***LOWERRE-BARBIERI, SUSAN K.; LLOPIZ, JOEL; BICKFORD, JOEL; WALTERS, SARAH L.**

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Spotted seatrout spawning activity: does it differ between pass and estuarine spawning sites?

Spotted seatrout are considered to be predominantly estuarine spawners throughout most of their range, although some pass spawning has been reported in Louisiana. A capture-based three-year study (2000-2002) was conducted in Tampa Bay, Florida, on spotted seatrout reproduction. Although actively spawning females were collected both within the lower bay and at the mouth of a pass to the Gulf of Mexico, the level of reproductive activity associated with these two areas differed. At the pass spawning site, 96% of the females were hydrated (meaning they would spawn that night), but at the estuarine sites only 14% were hydrated. Also, spotted seatrout were collected at the pass site only during the spawning season and mostly during the evening (peak spawning time), but spotted seatrout were collected at the estuarine sites throughout the year and in both morning and evening. It is not clear whether fish spawning at the pass site show fidelity to this site or whether they mix with estuarine spawning groups during the spawning season. However, sex ratios and average size and age differed at the pass site. The sex ratio of evening gillnet sets was

skewed towards females (62% female: 38% male) at the pass site. Comparable collections from estuarine sites showed the opposite pattern, with 57% male and 43% female. Average size and age of fish from the pass site were greater (407 mm TL and 3.4 years) than those from estuarine sites (359 mm TL and 2.8 years). These differences suggest that all spotted seatrout spawning sites are not created equal.

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Ontogenetic development of feeding behavior in two elasmobranchs: do anatomical constraints canalize behavioral capacity?

Early ontogeny is a time of rapid anatomical, physiological, and behavioral development and the degree of synchrony between anatomy and behavior during this period can influence individual survival. Understanding the ethomorphological development of feeding during early ontogeny is important because nutrient acquisition influences every aspect of organismal biology. A one-year longitudinal feeding study was conducted for two elasmobranch species: the whitespotted bambooshark *Chiloscyllium plagiosum* and the leopard shark *Triakis semifasciata*. To quantify changes in cranial anatomy and morphology, several external characters associated with the feeding apparatus were measured weekly. To quantify feeding behavior, individuals were filmed weekly using a high-speed digital video camera as they consumed various prey types. The cranial morphology of *C. plagiosum* exhibited primarily isometric growth and little change in shape through ontogeny. The cranial morphology of *T. semifasciata*, however, was dominated by allometric growth, producing greater changes in shape. These changes included an anterior displacement of the mouth and the development of a relatively narrow, shallow head profile. Although intraspecific differences both at discrete times and when comparing trajectories across ontogeny complicated comparison, modulation in response to prey attributes was clearly evident in *T. semifasciata* (e.g. faster, less ram-dominated kinematics for live prey) but was broadly absent in *C. plagiosum*. The capacity to perform diverse feeding behaviors throughout ontogeny is not constrained by anatomical development in *T. semifasciata* but tends to be canalized toward greater stereotypy in *C. plagiosum*. A plastic, functionally-generalized feeding apparatus and repertoire may benefit *T. semifasciata*, a common denizen of estuaries, by allowing exploitation of diverse prey in variable environments using different behaviors over ontogeny. Morphological conservation of the feeding apparatus throughout ontogeny in concert with honing of its feeding repertoire, however, may allow *C. plagiosum* to exploit numerous crevice-dwelling reef organisms throughout ontogeny using a single specialized behavior. **AES GRUBER**

***LUCKENBILL, KYLE R.; SABAJ, MARK H.; LUNDBERG, JOHN G.**

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The good, the bad, and the ugly: Imaging catfish primary types at ANSP

A total of 257 primary type specimens of 192 species of siluriforms present in the Academy of Natural Sciences Ichthyology Collection were photographed as part of the All Catfish Species Inventory supported by the National Science Foundation. Specimens were photographed in dorsal, ventral and lateral views in a photo tank (for small specimens) or on a pane of glass (for larger specimens) using a Nikon 4500 digital camera. The raw images were darkened and/or lightened to best represent the actual specimen, cleaned of blemishes, sharpened and placed on a uniform background with an appropriate scale bar using Adobe Photoshop. Examples of primary type images and specimen data, guidelines for digital photography of specimens and a detailed description of the techniques developed during this project will be presented (all of this information is available on the ACSI website at <http://silurus.acnatsci.org>). The next phases of the imaging project are to radiograph all siluriform type specimens and to photograph the paratypes in the collection.

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Fishes of the Rio Ventuari

An All Catfish Species Inventory funded expedition to the lower, middle, and upper Rio Ventuari, was conducted in March and April, 2004 with the goal of collecting undescribed species of catfish. This goal was achieved via collections of potential type material for at least 37 putatively undescribed species of catfish. Loricariid catfishes were particularly diverse, totally 38 species, 13 of which were undescribed. Also discovered was an exploitive ornamental fish trade harvesting loricariids from the lower Ventuari, and a biogeographically significant faunal barrier at Salto Tencua in the upper Ventuari. The Rio Ventuari is a major tributary of the upper Rio Orinoco, draining a large portion of the western Guyana Shield, and the discoveries made during this expedition contribute substantially to understanding of the biogeography of the Shield and the distribution of fishes throughout the Guyanas. This expeditions discoveries and their relevance to Neotropical fish conservation and Guyana Shield biogeography will be discussed.

***LUPTON, QUENT; FORESTER, DON**

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Initial herpetofauna responses to a created wetland: Implications for conservation and management

Amphibians and reptiles are experiencing a global decline in both numbers of species and population sizes. The loss of suitable habitat is a leading cause of

these declines. One technique used to guard against this loss is the creation of new habitats. In 2003, The Nature Conservancy constructed a series of vernal pools and replanted the native tree species on prior agricultural lands on the Delmarva peninsula in Maryland. In 2004, monitoring of this restoration project was initiated with the goal of determining what species of herpetofauna would colonize these created wetlands and uplands, and at what rate. Monitoring was also conducted in an adjacent mature forested wetland complex, which serves as the reference site for this study. Species richness in the first year of the restoration project was nearly even between the restoration and reference landscapes. However, the species composition was dissimilar between landscapes and abundances were higher in the reference site. Initial results from the first year of monitoring also showed a rapid colonization by anuran species, with successful breeding. In the 2005 field season we plan to reallocate sampling effort and perform additional methodologies to better document species that may be under-represented in the current data. Also, additional methods will be employed to better sample the herpetofauna assemblages of the upland areas of the reference and restoration sites. These data will be used to better determine the value of habitat creation/restoration as a tool for the conservation of herpetofauna.

***LUTTON, BRAM V.; CALLARD, IAN P.**

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The elasmobranch epigonal-ovarian complex (EOC): Regulation of leukocyte turnover by sex hormones

In mammals, it is well known that sex hormones affect both the innate and acquired immune systems by up- or down-regulation of the cells and factors they produce. It has been shown that, in general, estrogens hypersensitize the immune system while androgens and progestins are thought to down-regulate immune function. The cartilaginous fish (sharks, skates, and rays) offer a novel approach to the study of endocrine-immune interactions. These are the only species in which the gonads are directly associated with an autonomous immune tissue, the epigonal organ. Furthermore, the constant turnover of immune cells, via regulation of leukocyte proliferation and apoptosis, is critical for maintenance of homeostasis. To test whether sex hormones have an effect on cellular turnover of the epigonal organ, we utilized immunohistochemical (IHC) techniques to investigate apoptosis (TUNEL) and proliferation (proliferating cell nuclear antigen, PCNA Ab) of this unique leukopoietic tissue from reproductively active (RA) vs. non-reproductively active (NRA) little skates (*Leucoraja erinacea*). IHC analyses showed that that RA animals exhibited greater apoptosis than NRA animals, while the opposite was true for proliferation, suggesting a potential effect of sex hormones. We then used *in vitro* experiments to test the effects of 10⁻⁵M estradiol (E2), progesterone (P4), testosterone (T), and dexamethasone (Dex) on apoptosis and proliferation of epigonal leukocytes. Tritiated thymidine incorporation, DNA fragmentation, and labeling of leukocytes with caspase-3 Ab demonstrated a significant influence of sex hormones on immune cell turnover. This is the first study to demonstrate a reproductive endocrine-immune interaction in an elasmobranch species. It is likely that this association illustrates, in part, how these animals have survived for over 400 million years to become the oldest extant jawed vertebrates. Investigation of this novel association offers insight into the mechanisms behind both physiological and pathophysiological

influences of sex hormones in higher vertebrates, including humans.

LYNCH, ABIGAIL J.; LEMOND, LEE J.; *KOPENY, MARK T.; GRADY, JAMES M.; MATTHEWS, WILLIAM J.

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Conservation status of the spotted form of the Margined Madtom *Noturus insignis*

A unique, spotted form of the widely distributed Margined madtom, *Noturus insignis*, occurs in the upper Dan River, a tributary to the Roanoke River in Virginia and North Carolina. The spotted form was initially discovered in the upper Dan River, Patrick County, Virginia, in 1979. In surveys conducted between 2000 and 2004, we found that the spotted form also occurs in two major tributaries of the Dan River; the South Fork Mayo River and the Smith River. The objective of our investigation is to determine if the spotted form warrants conservation status as an evolutionarily significant unit. Our morphological and molecular analyses are based on Margined madtom populations sampled in twelve river drainages from South Carolina to New Jersey, including spotted individuals from populations in the upper Dan River system. Spotted individuals collected in and above the Dan River gorge in Patrick County differ morphologically from typical (non-spotted) individuals in eye diameter and in the arrangement and number of teeth of the posterior border of the pectoral spine. Preliminary analysis indicates the spotted form may also differ in the number of pre-anal vertebrae. We have not, as yet, detected genetic differentiation in the spotted form. Within- and between- population variation occurs in ten allozyme loci, but does not correlate with phenotypic (spotted vs. non-spotted) variation. The spotted form is not reciprocally monophyletic based on sequence analysis of a 400-bp region of the mitochondrial NADH2 among approximately 60 individuals and 15 haplotypes. Our interim recommendation, pending completion of our investigation, is that the spotted form of the Margined madtom be managed as an evolutionarily significant unit.

***LYNN, SCOTT G.**

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Cloning and expression of genes associated with sexually dimorphic growth in yellow perch (*Perca flavescens*)

Yellow perch (*Perca flavescens*) exhibit a unique estrogen-dependent, sexually dimorphic growth pattern wherein females grow faster than males. Estrogen (not androgens) stimulates growth in females and, to a lesser extent, males with a partial feminization of the endogenous endocrine system. The growth promoting effects of estrogen (E2) are not noticeable until a body size of 80-110 mm total length (TL), which is also when a sexually dimorphic growth rate becomes evident. This critical period coincides with the development of gonadal function and suggests there is an upregulation of receptors (estrogen receptors) on target

tissues (ovary, liver or pituitary) and a coinciding increase in tissue expression of growth factors. Endocrine genes associated with sexual development, reproduction and growth include the pituitary hormones (growth hormone (GH), prolactin (PRL) and somatolactin (SL)), the growth hormone intermediates (insulin-like growth factors-I & -II (IGF-I & -II)), the estrogen receptors (- & -ERs) and aromatase. I have successfully cloned these endocrine genes of interest (GH, PRL, SL, IGF-I & -II, - & -ERs, aromatase and -actin) in yellow perch and have developed real-time quantitative PCR assays to measure gene expression levels. Sex-specific tissue (pituitary, liver and ovary) gene expression levels from spring (May) and fall (October) yellow perch are being measured from a natural population in Lake Erie. Also, similar tissues were sampled from newly hatched yellow perch on a 6-week schedule for 1 year (through the 80-110 mm TL range) to measure sex-specific tissue gene expression levels. Comprehensive endocrine studies (tissue & sex-specific, seasonal and developmental gene expression levels) on yellow perch will yield predictive tools in the fisheries management and aquaculture of the species, as well as provide robust, predictive capabilities to other species of teleosts as a general template for estrogen-dependent physiological processes. **STOYE PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY**

***MA, GWO-CHIN; TSAO, HSIEN-SHAO; YU, HON-TSEN**

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Molecular systematics, population subdivision and karyotype evolution of the genus *Zacco* (Cyprinidae) in Taiwan

Zacco pachycephalus and *Z. platypus* are two species of Asian freshwater minnows (Cyprinidae) found in Taiwan. The former is endemic to Taiwan, while the latter is widespread in East Asia, including Japan, Korea, China and Taiwan. Although previous studies on these fishes based on morphology have resulted in differing taxonomic conclusions, the characteristic of genetic component, at both intra- and interspecific levels, and pattern of population subdivision have not been examined extensively in a molecular framework. Here, representatives of 16 sampling locations throughout the range of both taxa in Taiwan as well as one and one reference *Z. platypus* population from Japan and China, respectively, were examined. Mitochondrial D-loop sequences, polymorphic microsatellite loci and AFLP were used as molecular markers. Four genotypic groups with regionally geographical overlaps were recovered in analyses of the data. Two groups (A1 and A2) correspond to the previously recognized *Z. pachycephalus*, while the remaining two (groups L1 and L2) comprise *Z. platypus*. Phylogenetic relationships among these groups supported that groups A1 and A2 of *Z. pachycephalus* are reciprocal monophyletic groups but groups L1 and L2 of *Z. platypus* are not. Results of pairwise distance comparisons for mitochondrial DNA sequence divergences suggest the four *Zacco* groups probably represent four different species. Population genetic analyses for mitochondrial and microsatellite data are consistent with north/west subdivisions in Taiwanese populations for group A1 of *Z. pachycephalus* and groups L1 of *Z. platypus*. A further study based on phylogenetic analysis of mitochondrial D-loop sequences and karyotypic analysis of these genotypic groups supports a sharp increase of the chromosome number involving in the speciation of *Zacco*.

MABEE, PAULA M.

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Evolution of developmental traits in the Centrarchidae

Considerable resolution in the phylogenetic relationships among centrarchids has been gained in recent years with the influx of molecular data. A reexamination of the evolution of developmental morphology within the context of these phylogenies reveals new patterns of stasis and variation in traits such as teeth, serration, lateral line bones, and pigmentation. The substantial molecular data from developmental studies of zebrafish and other model vertebrates pertaining to the development of meristic series such as branchiostegal rays, vertebrae, and fin rays, is here related to patterns of homology and homoplasy in centrarchid evolution. Such comparisons point to test cases for the underlying mechanisms. Directions of evolutionary change in morphology were compared with those from development on the new trees for centrarchids, and the level of concordance, as expected from the phylogeny independent test of Mabee (1993) fell within the predicted range. The classes into which types of developmental change may be categorized (e.g. terminal addition, terminal deletion) and their frequencies in centrarchid evolution are reviewed from the standpoint of what is now known about the molecular controls over growth and development. Centrarchids, because of their well-resolved phylogenetic relationships and their prominent position and availability in North American freshwaters present a set of fishes in which underlying mechanisms of devo-evo may be usefully further explored.

MACESIC, LAURA J.

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Electric organ morphometrics of the lesser electric ray, *Narcine brasiliensis*

All elasmobranchs have the ability to detect electricity, however only the Rajiformes are capable of bioelectrogenesis. Within this order, skates use their small electric organs to emit weak electric organ discharges (EODs) involved in communication, whereas electric rays of the subfamily Torpedininae emit strong EODs from their large, kidney-shaped electric organs during prey-capture. The lesser electric rays of the subfamily Narcininae are capable of producing both strong and weak EODs from their large, kidney-shaped main electric organs and their small accessory organs respectively; however, the function of both of these types of discharges remains unknown. My goal is to characterize the main electric organ discharge and to determine how both the main and accessory EODs are employed behaviorally. Requisite to this goal is a morphometric study to examine possible sexual dimorphisms or ontogenetic changes in the electric organs. Morphometrics obtained from the representative species, *Narcine brasiliensis*, include: disc width, total length, total mass, main electric organ mass, accessory electric organ mass and number of main electric organ electroplaques. The proportion of EOD generating mass relative to the total body mass, herein referred to as the electro-somatic index (ESI, expressed as percent), was calculated for both main and accessory electric organs (MESI and AESI respectively). Mean MESI of *N. brasiliensis* was $13.69 \pm 0.63\%$ SE (n=15) and mean

AESI was $0.10 \pm 0.01\%$ SE (n=15). Main and accessory electric organ masses and the number of electroplaques in the main electric organ correlate positively with size morphometrics. In addition, the AESI demonstrates a positive allometry with body size, whereas the MESI is negatively allometric. None of the morphometric characters were sexually dimorphic. Future electrophysiological and behavioral experiments will investigate the function of the main and accessory electric organs to elucidate how they are employed in the natural history of this species. **AES CARRIER**

***MACKESSY, STEPHEN P.; HEYBORNE, WILLIAM H.**

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Venoms among non-venomous snakes: Biological roles of the venom of the Brown Treesnake

Within the last several years there has been a significant increase in interest in venoms from snakes traditionally included in the family Colubridae. Biochemical and pharmacological investigations of various species have proved unequivocally that colubrid venom components are homologs of numerous toxic proteins found among venoms of elapid and viperid snakes. However, our understanding of many aspects of both biochemistry and biological roles for most colubrid venoms is quite rudimentary. To address this general paucity of information, we have focused our attention on the venom of a common invasive species, the Brown Treesnake (*Boiga irregularis*). This large rear-fanged colubrid snake is also a constrictor, and the question of relative importance of venom versus constriction is relevant to understanding the trophic role of venoms among colubrid snakes, particularly since the low toxicity of venom toward inbred mice has been used to argue against a trophic role for venom in this species. Our goal was to determine the identity of all major proteins in the venom of the Brown Treesnake and to relate this information to the role of venom during feeding. To this end, venom was subjected to numerous analyses, including comparative toxicity assays, enzyme assays, one and two dimensional electrophoresis, mass spectrometry, and protein and DNA sequencing. Two dimensional electrophoresis indicated venom complexity much greater than suggested by 1D electrophoresis, but Brown Treesnake venom is considerably less complex than most front-fanged snake venoms in terms of numbers of protein components. We have determined the activities of most major proteins, and venoms contain metalloproteases, acetylcholinesterases, CRISPs (a relatively recently described family of ubiquitous venom proteins) and numerous actual and putative neurotoxins. The presence of taxa-specific toxins in the venom indicates positive directional selection for potent toxic effects toward native prey, confirming the trophic role of colubrid venoms for facilitating prey handling.

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Tissue types reflect trophic inferences from stable isotopes in sharks

Food-web relationships in marine systems have traditionally been defined through stomach-content analysis but biochemical techniques have recently emerged to validate and broaden temporal diet patterns. Stable-isotope analysis has become a practical tool for evaluating these relationships in aquatic systems, however, routine sampling of muscle tissue captures only part of the trophic information available from each animal. We compared ^{15}N and ^{13}C values among liver, muscle and cartilage in blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), and common thresher (*Alopias vulpinus*) from the northwest Atlantic to show how multiple-tissue sampling captured feeding relationships which would have been invisible to muscle tissue alone. Specifically, we demonstrated evidence of a known spring cephalopod to bluefish (*Pomatomus saltatrix*) diet switch in shortfin mako, and found that blue shark and common thresher have consistent diets throughout the year. We concluded that consistency observed among stable-isotope values in multiple tissues implied that the fish were in steady-state with the isotope ratios of their diet and that multiple tissues should be used in trophic assessments of large pelagic fishes. Further experiments to quantify the turnover of stable isotopes in different tissues and species are needed to improve the accuracy of stable-isotope analyses. **AES GRUBER**

***MADAD, ASMA Z.; BURKE, RUSSELL L.; WIDRIG, AMANDA L.; VALENZUELA, NICOLE**

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Application of geometric morphometric sex identification techniques to Diamondback Terrapin hatchlings

Development of accurate, non-lethal sexing techniques for turtle hatchlings is important especially when studies involve vulnerable species. The most direct techniques of sex-identification usually involve sacrifice of the hatchling for physical examination of gonadal tissue, which can be time consuming as well as counter to conservation concerns. Landmark-based geometric morphometric techniques have been used successfully in sexing hatchlings of painted turtles (*Chrysemys picta*) and giant river turtles (*Podocnemis expansa*). Here we analyzed digitized photographs of newly emerged hatchling diamondback terrapins (*Malaclemys terrapin*) from Jamaica Bay, New York, using 31 landmarks on the carapace and 12 landmarks on the plastron. Our analysis is the first to attempt to use plastron morphology for sexing, and we assess the accuracy of plastron vs. carapace morphology for use in sex identification. Possible complications discussed include the obscuring of landmarks by the yolk scar and the incidence

of carapace malformations in the terrapin population under examination.

***MAGNUSSEN, JENNIFER E.; SHIVJI, MAHMOOD S.**

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Efficient genetic identification of species and geographic origin of body parts from CITES and/or legislatively protected shark species.

Heavy exploitation of sharks globally to satisfy the demands of the international fin market have resulted in trade in a few species considered particularly sensitive being restricted or controlled by national legislation or international accord (e.g. CITES). Despite these conservation efforts, however, trade in these species continues because law enforcement monitoring and surveillance is hindered by species identification problems. We present the development and application of a highly streamlined, robust, multiplex PCR assay for identification of basking shark (*Cetorhinus maximus*; CITES Appendix II) and sand tiger shark (*Carcharias taurus*; protected in the U.S. and Australia) body parts in trade. Given the spatially "patchy" nature of national protective efforts for some species, identifying the geographic origin of the traded products will be needed for legal enforcement, and will be informative for assessing geographic trends in exploitation pressure. To this end, we will present preliminary data on development of a combined nuclear and mitochondrial locus, multiplex PCR assay that simultaneously distinguishes species and ocean-basin of origin for the sand tiger shark. The results suggest that if appropriate levels of population genetic structure exist, it should be possible to simultaneously determine species and population of origin of shark body parts with a single tube PCR.

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A molecular phylogeny of the percoid superfamily Sparoidea based on the RAG1 gene

The percoid superfamily Sparoidea contains the families Nemipteridae, Sparidae, Centracanthidae, and Lethrinidae. Previous investigations have proposed phylogenetic relationships within this group using a limited number of outgroups from the polyphyletic Percoidei. In this study, we used approximately 1500bp of the nuclear recombination activating gene I (RAG1) to test both the relationships among the sparoid families and the monophyly of the superfamily within the Percoidei. We compared these molecular results to previous morphological findings, such as that of Carpenter and Johnson (2002), who used 54 morphological characters to elucidate relationships within the Sparoidea. Preliminary results show some support for previous hypotheses and also offer some novel interpretations. Future directions will include an increased taxon sampling from both within the Sparoidea and from other percoid families to more rigorously test the relationships within the putative superfamily and the monophyly of this group.

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Phylogenetic relationships of frog families and amphibian orders based on nuclear ribosomal genes

Phylogenetic relationships among frogs families and among the three orders of amphibians remain uncertain despite application of both morphological and molecular data to these questions. Nuclear ribosomal (rRNA) genes have been used previously to examine relationships within and among amphibian orders, though sequenced regions were generally short, and many aspects of the phylogeny remained unresolved. I sequenced representatives from two-thirds of frog families, plus salamander and caecilian outgroups, for 18S rRNA and portions of 28S rRNA. Additional sequences, including outgroups, were taken from GenBank. For each gene, ten percent of the sites were phylogenetically informative. The genes were similar in resolution of relationships within Anura, but 28S generally had higher levels of support. Analyzed in combination, the nuclear rRNA phylogeny was largely congruent with previous molecular and morphological hypotheses for frog family relationships. The two genes differed in relationships among the three orders of amphibians, and in combination had moderate support for grouping Anura+Caudata. As shown in previous studies, these genes are highly conserved making them appropriate for examining ancient divergences, like those observed within frogs and among amphibians. With few variable sites, however, large amounts of sequence data evolving in a similar manner would be necessary to find strong support for relationships. Further, rate changes in one or a few lineages, even of apparently small magnitude, can have large effects on their phylogenetic position, because of the small number of informative characters.

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The Shortfin Mako Shark, *Isurus oxyrinchus*, from Portuguese waters - foraging ecology, population dynamics and reproduction

The shortfin mako, *Isurus oxyrinchus*, is caught in the eastern North Atlantic as a steady bycatch of the surface drift longline fishery, directed to swordfish, *Xiphias gladius*. Teleosts showed to be the principal component of this shark's diet, occurring in 87% of the 112 stomachs sampled (vacuity index 12%) and accounting for over 90% of the weighted contents. Crustaceans and cephalopods are also common prey of *I. oxyrinchus*, while other elasmobranchs were present in its diet in low percentages. Young-of-the-year and juveniles show less constancy in diet composition throughout seasons when compared to adults. Reproductive traits revealed median length at maturity for males to be 185 cm fork length, with only 9 mature males caught. The only mature female was 290

cm and the larger immature female 210 cm fork length, suggesting maturity is reached in this interval. Cohort analysis indicates summer as the most probable parturition season, with smallest sharks (64 and 66 cm fork length) caught in July. Individuals larger than 120 cm fork length present sexual size dimorphism with larger females and sex ratio is biased towards males 1.8:1 (M:F) among juveniles. Sexual size dimorphism may account for the low number of mature females sampled, making them unavailable to fishing gear, rather than being absent from the study area. **AES GRUBER**

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A comparison of photoperiod related activity patterns between two South Florida toads (Anura: Bufonidae)

Early natural history notes (Hamilton, 1955; Wright & Wright, 1949; and Duellman & Schwartz, 1958) described *Bufo quercicus* as diurnal. These descriptions are postulated upon field observations, but have never been confirmed empirically. We collected *B. quercicus* adults and larvae as well as adult *Bufo terrestris*, a putatively nocturnal toad, near Everglades National Park, Florida. The goals of this study were to: 1) verify these earlier accounts experimentally. 2) compare activity patterns between the two bufonids, and 3) elicit evidence of a potential ontogenetic shift in activity patterns before and throughout metamorphosis. We used time-lapse videography to sequence toad and larvae movements every 30 seconds for 24 hours. Our preliminary data indicates that *B. quercicus* is more active during the day than *B. terrestris*. However, *B. quercicus* also displays significant nocturnal activity.

***MANDRAK, NICHOLAS E.; STATON, SHAWN K.**

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Identifying conservation hot spots for freshwater species at risk in Canada

Priority watersheds for protecting freshwater species at risk in Canada were identified by creating a conservation hot spot index based on the biodiversity of fishes and mussels and the threats to these taxa. Of some 229 fish species and 55 freshwater mussel species found in Canada, the highest diversity is found in the Great Lakes basin where species diversity peaks at 102 fish and 34 mussel species at the watershed level. Patterns of species at risk listed by COSEWIC mirror this pattern with richness peaking at 16 fish species and 8 mussel species in the watersheds of southwestern Ontario. Such diverse aquatic communities in this region are primarily attributed to moderate climatic conditions and biogeographic history. Unfortunately, these areas of high biodiversity occur in the Great Lakes where threats from human impacts and aquatic invasive species are most severe. The human impacts were summarized for each watershed using a human stress index that incorporated measures of land use, population size and road density. The impacts of aquatic invasive species were summarized as the total number of introduced fish species by watershed. The conservation hot

spot index was the sum of the equally weighted fish and mussel richness, fish and mussel species-at-risk richness, introduced fish species richness and human stress index. This analysis identified watersheds in the southern Great Lakes basin and southern Pacific Coast as priority watersheds for conservation.

***MANIS, CHRISTOPHER B.; WILSON, THOMAS P.**

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Community ecology of an aquatic turtle assemblage in the Tennessee River Gorge

We report on a five year study (2000 to 2004) utilizing traditional mark-recapture census techniques to determine the diversity, richness, and ecological status of a riverine turtle assemblage present in the Lower Tennessee Watershed. Specifically, we concentrated our research efforts in the Tennessee River Gorge (TRG) which extends 42 kilometers from Williams Island to Nickajack Dam, and includes Hamilton and Marion Counties, respectively. A concerted trapping effort was sustained over the entire project, but efforts were maximized during the first and fifth field seasons. To date, 2,225 turtles representing nine species while encompassing four families have been recorded. Overall, the Cumberland slider (*Trachemys scripta*) constituted proportionally greater numbers and biomass than the other eight species combined. The stinkpot turtle (*Sternotherus odoratus*), river cooter (*Pseudemys concinna*) and common snapping turtle (*Chelydra serpentina*) decreased in relative abundance, respectively. Generally, the snapping turtle and river cooter ranked as second and third in biomass. However, analyzing the dataset using our two most distinct communities that represented years one and five, we were able to determine and compare measures of evenness and heterogeneity. In sum, the Cumberland slider, stinkpot, river cooter, snapping turtle, ouachita map turtle (*Graptemys ouachitensis*), and the common map turtle (*Graptemys geographica*) were collected at both locations. However, the stripeneck musk turtle (*S. minor*), spiny softshell turtle (*Apalone spinifera*), and painted turtle (*Chrysemys picta*) were documented only at the north study site. Cumberland sliders were the most abundant species encountered at both sites, and this was followed by the stinkpot, river cooter, and snapping turtle. Comparative site diversity was not equal, but this disparity did not adversely affect turtle similarity coefficients of the communities, respectively. Additional ecological parameters will be presented as they relate to the conservation of freshwater turtle assemblages.

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Herring hearing does not include ultrasound

Recent studies have shown that some clupeid fishes, including shad and

menhaden, can detect ultrasound (sound with frequencies higher than 20 kHz) and actively avoid it. However, other clupeids, including sardines and anchovies, do not detect ultrasound. The hearing abilities of herring are of particular interest because of their commercial importance, our reliance on acoustics to monitor their populations, and behavioral evidence of responses to high frequency sound by some clupeid species. We measured the hearing sensitivity of Pacific herring (*Clupea pallasii*) using the auditory brainstem response (ABR) and found that they were unable to detect ultrasonic signals at received levels up to 185 dB re 1 Pa. Herring had hearing thresholds at lower frequencies (100-5000 Hz), which were typical of other non-ultrasound detecting clupeids. This lower frequency hearing sensitivity could explain the results of several earlier studies showing responses to broad-band sounds.

***MANSFIELD, KATHERINE L.; MUSICK, JOHN A.**

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Sea turtle surfacing behavior and aerial census: How seasonal 'sightability' affects juvenile density estimates in Virginia

The Chesapeake Bay serves as a seasonal foraging habitat for thousands of juvenile loggerhead (*Caretta caretta*) and hundreds of juvenile Kemp's ridley (*Lepidochelys kempii*) sea turtles. Aerial surveys indicate that turtle densities peak during the spring as turtles migrate into the Bay. Turtles are visible to aerial observers only when swimming at the water's surface. Historically, a correction factor is applied to density estimates accounting for turtles below the observable surface based on the percent time turtles spend at surface during the summer and fall: 5.3%. For each turtle at the surface, 18-19 are below. Springtime surfacing behaviors of juvenile loggerheads (n=8) and Kemp's ridleys (n=5) were determined during 2002-2004 using radio/acoustic telemetry. Mean daytime loggerhead surfacing times ranged between 9.9% (+/- 2.9% SDEV; 1:10) and 25.0% (+/- 16.3% SD; 1:4). Mean Kemp's ridley surfacing times ranged between 30.0% (+/- 25.8% SD; 1:3) and 32.9% (+/- 23.1% SD). There were significant differences among all individuals tracked (ANOVA, p< 0.05). All surfacing rates were higher than historic summer/fall rates (5.3%). Therefore, turtles observed in the spring are more likely to be counted during aerial surveys. Large differences (1:18 vs. 1:10, 1:4 or 1:3) in seasonal sea turtle 'sightability' bias historic abundance estimates. Aerial surveys were conducted between 2001-2004. Predicted surfacing rates were calculated using simultaneous linear equations assuming constant abundance. Peak predicted springtime 'sightability' ranged from 21.0% to 28.0%. The estimates for the summer/fall months closely modeled historic surfacing rates of 5.3%, indicating a behavioral shift between the spring and summer/fall months: a decrease in 'sightability' due to an increase in benthic feeding behavior. Using the historic correction (5.3%), mean springtime population estimates ranged between 1,600-5,800 turtles. Modeling sea turtle 'sightability' at 25.0%, these estimates were dramatically reduced to 350-1,250 turtles, indicating that springtime sea turtle densities in Virginia have been overestimated. **SSAR SEIBERT CONSERVATION**

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The effect of drying regime on the distribution of an endangered salamander and its invasive predators

Invasive species have been implicated in the decline of many native species. However, the mechanisms underlying successful invasion and species replacement are generally poorly understood. In the San Rafael Valley in Arizona, cattle ponds designed to hold water year-round have replaced seasonal marshes, and this disrupted drying regime has facilitated invasion by disturbance-intolerant predators that negatively affect native Sonoran tiger salamanders, *Ambystoma tigrinum stebbinsi*. We investigated the relationships among pond drying frequency, presence of introduced fish and bullfrogs, and presence of tiger salamander populations. Both fish and breeding bullfrog populations disappeared from ponds following drying. Pond drying negatively affected salamanders, but not to the same extent that it affected fish and bullfrogs. Metamorphosed bullfrogs ate salamander larvae in laboratory and field experiments, and the risk of local extinction among salamander populations was increased by introduced fish. Once fish eliminated salamanders from an aquatic habitat, salamanders seldom reappeared unless fish were killed by drying. We developed simple models to predict changes in salamander, fish, and bullfrog distributions with changes in pond drying frequency. These models demonstrate that decreases in pond drying frequency could negatively affect salamanders by leading to increases in disturbance-intolerant fish and bullfrogs, but increases in drying frequency could negatively affect salamander populations by preventing salamander breeding. These results suggest that manipulation or restoration of disturbance regimes may be useful in managing for native species threatened by invasive species.

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Resource level affects matrotrophic provisioning in Largespring Gambusia

Fishes of the livebearing genus *Gambusia* provision developing embryos both by the production of large, yolky eggs (lecithotrophy) and by post-fertilization transfer of nutrients (matrotrophy). In such species with dual provisioning, matrotrophy may increase potential brood size by allowing production of smaller eggs without compromising offspring size, or it may allow females to increase offspring size in response to increased resources. We examined effects of resource levels on matrotrophy and offspring size in Largespring *Gambusia*. Females that had been maintained under the same laboratory conditions for 7 months, were randomly assigned to high (daily) or low (every three days) feeding schedules for 3 months, after which we quantified mother-to-embryo nutrient transfer by injecting females with tritiated leucine and assaying embryos for radioactivity. Many females in this study had only partially fertilized broods,

which allowed us to assay size of eggs as well as embryos. Although resource level did not affect egg size, females maintained on the daily feeding schedule produced larger embryos and showed higher levels of provisioning. Thus, it appears that matrotrophy in Largespring *Gambusia* allows females to adjust offspring size in response to resource availability.

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Phylogenetics and historical biogeography of the western whiptail lizard *Aspidoscelis tigris* in Baja California, Mexico

Aspidoscelis tigris is an abundant and conspicuous lizard of the arid lands of North America. However, our understanding of the relationships among the morphologically differentiated populations/subspecies is still uncertain. One longstanding systematic problem involves the southern Baja California *A. t. maxima* (Cape region) and *A. t. rubida* (northern & central Baja CA Sur). Historically, the distinctive *A. t. maxima* was recognized as a full species; however, the two southern Baja forms are now considered conspecific. MtDNA data (ND1, ND2) are being used to study the phylogeographic patterns within *A. tigris*, with emphasis on the Baja populations. The dataset consists of ≈1750 aligned nucleotide positions (532 informative), with >110 individuals for ND1 and >70 individuals for ND2 gene. These data were analyzed using partitioned Bayesian methods, resulting in a phylogeny that divides all *A. tigris* populations into two major clades (Northern Clade and Southern Baja California Clade). The strongly supported Northern Clade contains all U.S. populations and those from northern-central Baja (and Sonora). The weakly supported Southern Baja California Clade contains three strongly supported subclades: 1) the Cape region, 2) southern Baja California Sur (north of the Cape), and 3) the Chihuahuan Desert. The ND2 sequences for all three subclades exhibit a derived three amino acid insertion (absent in all other *A. tigris* populations and outgroups) which increases our confidence in this clade. The Cape region subclade (= *A. t. maxima*) is sister to the geographically proximate *A. t. rubida* (=Southern Baja California Sur subclade). The Chihuahuan Desert subclade (= *A. t. marmorata*) of mainland Mexico is sister *A. t. maxima* + *A. t. rubida* group. However, this specific relationship is not strongly supported. The overall phylogeographic patterns within *A. tigris* are concordant with studies of other Baja taxa, implicating historical vicariant processes during the Miocene, Pliocene and Pleistocene.

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How many species of *Poecilia* are there in Tobago?

In the process of studying the fish fauna of Tobago, WI, we have collected specimens and found literature references concerning, or examined museum specimens of *Poecilia reticulata*, *P. vivipara*, *P. parae*, *P. picta*, and *P. sphenops*. The last of these species was apparently introduced into the Merchiston River near Speyside in the 1970s. Of the four possibly native species reported in the literature, two of these are known to us only from literature records that may be based on misidentifications. Further, there is a complex of populations in Tobago which are similar to *P. picta* but species placement is uncertain. We are using molecular and morphometric approaches to address whether any of these forms are native and to which species they can be properly assigned. In addition to discussing systematic placement of Tobago *Poecilia*, we discuss zoogeographic implications of our data in relationship to similarities between the Tobago *Poecilia* fauna and either Trinidad or mainland South America.

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Intraspecific phylogeography of the Least Brook Lamprey

The Least brook lamprey (LBL), *Lampetra aepyptera*, is a nonparasitic species native to the eastern United States which resides in small streams within the Mississippi, Mobile Basin, and Atlantic slope drainage systems. Molecular evidence suggests that it shares a common ancestor with a European species, *L. fluviatilis*. We investigated the phylogeography of the Least Brook lamprey by sequencing 351 bases of the mitochondrial ND3 gene and 347 bases in the non-repetitive portion of the mitochondrial control region. Samples from approximately 24 populations throughout the LBL's distribution were sequenced. 19 different haplotypes were detected at the ND3 region with an average sequence divergence of 3.9%. 16 different haplotypes with an average sequence divergence of 3.2% were detected at the control region. Several small (1-8 bases) indels were also detected in the control region. The populations of LBL formed a monophyletic group whose sister taxon was *L. fluviatilis*. Analysis of the ND3 data identified several well-supported clades within this monophyletic group; upper Ohio River, Alabama, Maryland, Missouri, Terrapin Creek (neotenic), western Tennessee, eastern Tennessee, Mississippi, and North Carolina. However, the relationships among these clades were not well-supported. The combined ND3 and control region data sets improved the resolution among the clades. Our data suggest that LBL consists of several undescribed species. However, a lack of morphological characters that could diagnose these taxa may make description problematic.

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The role of acoustic signals in chorus formation in treefrogs

Visiting a wetland or rainforest at night in the spring or summer guarantees an impressive experience: choruses of hundreds or even thousands of frogs of as many as 20 species. Choruses of frogs and insects are dynamic, socially complex communication networks, which vary in duration, species composition, density, and in the spatial arrangements of calling individuals. Choruses are also focal points for sexual selection, where males interact to obtain and maintain calling sites, and females locate and choose mates mainly on the basis of acoustic signals. Surprisingly, the factors influencing the onset of choruses and the location of aggregations of males within the general chorusing area have been studied very little. I have been studying the communication system of the Bird voiced treefrog, *Hyla avivoca* to understand the role of acoustic cues in male-male interactions. The focus of my current research is to investigate the role of acoustic signals in: (1) the onset of calling in aggregations of lek-breeding species (i.e. frog choruses); (2) the choice of the location of the aggregation; and the choice of a calling site within the aggregation. Lastly, I will (3) assess the consequences for males of settling near a neighbor that produces attractive calls versus settling near a male that produces unattractive calls by investigating the mechanisms and evolutionary benefits behind male-male call interaction and chorusing behavior by testing the mating in two-choice tests of females preferences. This research will provide information about the behavioral and reproductive ecology of *H. avivoca* and more importantly, will provide insights into the behavioral mechanisms and functions of male-male interaction and their possible effect on the evolution of chorus formation, sexual selection and male mating success in treefrogs.

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Herpetofauna of Reserva Ecológica Comunal Loma Alta (La RECLA), Guayas Province, Ecuador

The people of the Reserva Ecológica Comunal de Loma Alta in Ecuador are pioneers in preserving biodiversity and sustainable land use through ecology and biodiversity studies, land acquisition, and programs in management and education. Loma Alta lies in the transition between the Chocó and Tumbesian Eco-regions making it a very important ecological zone, as many of its biota shows characteristics and adaptations to either region. The lowlands (50-250m) are composed of mostly disturbed dry forests, while the higher altitudes (350-

800m) are known as Garúa Forest, or Mist Forest, a type of seasonal wet forest characterized by predominantly dry forest in the lower slopes and seasonally wetter forests at higher elevations. This forest is quite different from higher elevation and wetter Montane Tropical Cloud forests typical of the Western slopes of Andes of Ecuador. The area between 250 and 400 m is a transitional dry/moist forest. Garúa forests host a great degree of endemic organisms and a high number of species normally recognized from wetter areas. We are surveying the herpetofauna of this transitional dry/wet forest to promote low-impact species inventories, gather ecological and morphological data of its herpetofaunal biodiversity and promote knowledge and appreciation for these organisms in the community. Herein we report the results of our first visit to the reserve, which include 15 anurans (5 families), 7 snakes (2 families) and 9 lizards (5 families) for a total of 31 species. Of these, 3 anurans represent endemic endangered taxa, new localities for most the individuals, and range expansions for 2 snakes, 6 anuran and 2 lizards. Additionally we present behavioral and ecological information on a previously undescribed species of *Hyla*, temporarily assigned to the *H. albomargianta* group. This is the first survey of the herpetofauna of the Loma Alta Reserve.

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Microhabitat use by yellow-bellied watersnakes (*Nerodia erythrogaster flavigaster*), in an east Texas floodplain

I monitored ten sites representing differing microhabitats within an East Texas bottomland hardwood forest floodplain area for one year, using a combination of minnow traps, cover boards, and visual searches. Any *Nerodia erythrogaster flavigaster* found was categorized by location, time of day, and weather, along with basic physical characteristics and microhabitat characteristics of the capture site. After capture, I marked each snake with either a PIT tag, or scale clip to prevent recaptures biasing data. Physical data recorded on all new captures included: S/V length, weight, sex, any scars or disease, pregnancy, any food palpated, and amount of banding. Microhabitat characteristics included: distance to water, GPS location, type of vegetation, other animals present at site, and whether the capture occurred in a minnow trap, under a board, or under other cover. *N. erythrogaster flavigaster* in this area appear to use different microhabitats; large female snakes were much more likely to be found near large woodland pools, while adult males were more likely to be found near smaller pools or by flood channels. Juvenile of both sexes occurred in drier, more open areas, such as food plots and ATV trail edges.

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The Comic Snailfish: An abundant new species of *Careproctus* (Liparidae) from the Aleutian Islands

A new species of *Careproctus* will be described from nearly 100 specimens collected from along the length of the Aleutian Islands, during benthic trawl surveys conducted by the Alaska Fisheries Science Center. The new species was found at depths of 120 to 440 meters, near the maximum depth of the surveys. The Comic Snailfish has a prominent snout and, unlike the uniform coloration of other species of the genus, is mottled red, black, and white. It is most similar in body coloration to, and has been consistently misidentified as, *Temnocora candidus*, which differs in having a dorsal fin with a distinct anterior lobe, lower vertebral and median-fin ray counts, a rounded snout, and deeper body. The status of *Temnocora* will be discussed. We also compare the new species with other similar species of *Careproctus*, including *C. mollis*, known only from the type series, and *C. bowersianus*. Meristic and morphometric evidence suggests that a second similar species may also be present, a possibility that will be discussed in detail.

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Dwarf Seahorse (*Syngnathidae*, *Hippocampus zosterae*) habitat distribution and population biology in Tampa Bay, Florida: Engaging volunteers in the research process

This project was a partnership between researchers and community volunteers recruited through the University of Tampa, the Florida Aquarium, and from the general public to investigate the distribution and habitat preferences of dwarf seahorses (*Hippocampus zosterae*) and their pipefish relatives (syngnathid fishes) throughout the Tampa Bay Estuary System. Previous work investigating the population dynamics of dwarf seahorses in the Florida Keys determined that habitat variables such as seagrass species composition, blade height, and water flow were significantly correlated with seahorse presence. The Tampa Bay project has engaged community members directly in field research to generate a data set with which to test the habitat distribution model developed in the Florida Keys. Volunteers were trained to measure environmental parameters such as salinity and water turbidity, sample grass beds to census syngnathid populations and measure species diversity, photograph quadrats to measure seagrass quality, and collect samples for later analysis of sediment organic content, epiphytic cover, and chlorophyll/carotenoid content of seagrass blades. On a fine scale, the distribution of *H. zosterae* in Tampa Bay was patchy, similar to previous research. Seahorse populations in Tampa Bay were significantly correlated with seagrass beds dominated by tall-bladed turtle grass (*Thalassia testudinum*), similar to the patterns observed in the Florida Keys, but contrary to

previous research, slow water flow did not significantly predict seahorse habitat. In management plans concerning this IUCN Red Listed genus, conservation of habitat is critical. However, our data suggest that seagrass beds differ in their suitability as habitat and management plans will need to incorporate fine scale ecological variables in identifying sites to protect, and one way to generate the data necessary to identify habitat is to engage community volunteers.

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Do reservoirs alter fish communities in the creeks they drown?

There is evidence from isolated case histories in the literature to suggest that fish communities or species in streams whose lower reaches are drowned by formation of reservoirs may change more over time do fishes in similar streams not directly flooded by a reservoir. Lake Texoma, Oklahoma-Texas, was formed in the late 1940s by impoundment of the Red and Washita rivers, drowning the lower reaches of numerous small to medium-sized creeks. In several of these direct tributary creeks, we have observed declines in some species like *Cyprinella lutrensis*, *Pimephales promelas*, or *Pimephales vigilax* in our own sampling during the last three decades. We now use historical data from the 1920s, 1950s, 1960s, and our collections from the 1970s to the present, to ask for a large number of creeks if native fishes in creeks with lower ends drowned by Lake Texoma have changed more than the fishes in creeks that remain as direct tributaries to the Red River or the Washita River.

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A skeletochronological study of the longevity and age structure of the Mountain Yellow-legged Frog, *Rana muscosa*

We used skeletochronology to age 149 (67 females, 44 males, and 38 metamorphs) mountain yellow-legged frogs, *Rana muscosa*, from 13 locations (elevation ranged from 1509-3501 m) throughout their current range in the Sierra Nevada. Lines of arrested growth (LAGs) from excised toe bones were distinct in these high elevation frogs and each LAG was assumed to represent one year of age. Females ranged in age from 0-10 years (mean = 4.4 years) and males from 0-8 years (mean = 4.0 yrs). The skeletochronological age was that of the adult frog, and did not include the tadpole stage. Mountain yellow-legged frogs spend 3-4 years as tadpoles but no age markers are found in their cartilaginous skeletons, thus, their total ages including both tadpoles and adult stages ranged up to 14 years. Ages from sample sites at higher elevations (n=5 sites >3000 m) had the broadest range up to 10 years. In comparison, ages from sample sites at lower elevations (n=8 sites <3000 m) ranged up to 7 years. However at lower elevations, length and weight at age was higher. Mean masses and lengths of

frogs were greater from those sampled < 3000 m (n= 83, mean mass = 29.8 g, mean length = 60.4 mm) compared to those > 3000 m (n=66, mean mass = 14.8 g, mean length 47 mm). We found that location (elevation and location within the northern-southern Sierra Nevada range) was an important variable in the relationship between length and age; frogs from lower elevation sites were consistently larger at age when compared to higher elevation sites. This is the first ageing study of a Sierra Nevada amphibian, and compared to other ranid species, mountain yellow-legged frogs were found to be relatively long-lived and which has implications for restoration and recovery plans.

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Ecology of the Blanding's Turtle (*Emydoidea blandingii*) at a northern Illinois nature preserve

Habitat loss, degradation, and fragmentation caused by the pressures of urbanization are responsible for the decline of many aquatic turtle species in the United States. Populations that have survived in the wake of these pressures have become restricted to small isolated patches of habitat. For relatively long-lived turtle species, adults may persist, while the overall population continues to decline because of lack of reproduction and recruitment. Although Blanding's turtles (*Emydoidea blandingii*) were historically abundant in prairie wetlands of Illinois, habitat loss and wetland degradation have led to their decline. Pursuant to this decline, in 1998 *E. blandingii* was listed as threatened in Illinois. Since 1988 long-term capture/recapture techniques have been employed at Lockport Prairie Nature Preserve (LPNP). Here we report on population structure, size, sex ratios, and diet. We also provide recommendations for additional studies that are needed to adequately manage the LPNP population.

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The zoogeography of New World freshwater fishes: The book series

Nearly two decades ago one of the most influential publications for North American freshwater fishes evolved as a collaborative project edited by C. H. Hocutt and E. O. Wiley, *The Zoogeography of North American Freshwater Fishes*. It originated as a special symposium with ASIH and was successful for many reasons, one being strong interactions among participants before, at, and after the symposium. Contributions to the zoogeography book targeted specific regions of North America and provided tabular reviews of not only diversity of species known from different drainages and their status but also reviewed the

geologies/hydrologies of areas as pertaining to fishes, biogeographies (faunal similarities or phylogenetics), and fossil histories. Without doubt, this book quickly galvanized many academic disciplines, in addition to systematic and taxonomic ichthyology, to conduct research on North American fishes. As a result, the last twenty years have been extremely productive in North America with respect to inventories, conservation of fishes, phylogeny generation across taxonomic ranks, community ecology and evolution, and comparative biogeography. We are revisiting this concept but at a New World scale - uniting expertise from North, Central, and South America for the development of new volumes entitled *The Zoogeography of New World Freshwater Fishes*. This will be a community-based effort like the model for the zoogeography book; we invite participants willing to work together at an international scale but focusing on particular geographic areas and drainage systems to provide faunistic, geological, systematic, and biogeographical information for chapters of this initiative. We are in the planning stages of this initiative and invite participants and ideas on content and identification of chapters for Central and South America. This is an important initiative and is consistent with NSF initiatives in BS&I, REVSYS, PBI, and ATOL.

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Phylogeny of sunfishes and basses, Family Centrarchidae (Teleostei; Perciformes)

The Centrarchidae (sunfishes and basses) are a group of 31 species in nine genera endemic to North America. This family constitutes a major component of the ichthyofauna in most eastern North American warm-water ecosystems and are highly prized in recreational fisheries and aquaculture. In addition, centrarchids have been the focus of many behavioral, developmental, ecological, evolutionary, functional morphological, genetic and host-parasite coevolution studies. Surprisingly, despite the popularity of these fishes and their dominance in ecosystems and different studies, prior to the 21st century, very few phylogenetic hypotheses for this clade existed. Existing hypotheses conflicted not only for generic relationships but also interspecific relationships, the monophyly of the family, and the genealogical placement of the pygmy sunfishes in the current family Elasmobranchidae. Recent years, however, has brought extensive molecular data to the question of not only the relationships of the Centrarchidae to Elasmobranchidae but also intergeneric, interspecific, and intraspecific relationships. We review these various hypotheses that have been offered by different researchers and evaluate the general support for these various hypotheses.

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Diversity and evolution of Cypriniformes: Baseline assessment for the Tree of Life Initiative (Teleostei: Ostariophysi)

A recent, large-scale and international initiative has focused on the diversity and phylogenetic relationships of fishes of the Order Cypriniformes, commonly known as carps, goldfishes, coi, bream, minnows, chubs, dace, shiners, suckers, buffalo, loaches, or hillstream loaches. The currently recognized diversity in this order is in excess of 3,000 species; however, estimates of undescribed species worldwide is expected to eventually increase this diversity to nearly 5,000 species. This extensive diversity has been evaluated by many researchers for phylogenetic relationships. Earlier studies focused on morphological variation and molecular evidence derived largely from allozyme and isozymes. With the advent of technologies making DNA sequences more readily available many studies have targeted many species of Cypriniformes for species, generic, and family relationships; however, most of these studies have focused on a limited number of mitochondrial genes and regional diversity. Few studies incorporate multiple genes, multiple data types, or taxa from multiple geographic or continental areas to elucidate relationships across the order. We review some of these efforts and synthesize basic relationships of genera, subfamilies, and families within the order derived from character-based and phylogenetic analyses, with the basic objective being to clearly represent our current understanding of relationships and classification in the order. This research is part of the Cypriniformes Tree of Life (CToL) initiative supported by the NSF ATOL program (www.cypriniformes.org).

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Characterization of eight microsatellite loci in a captive population of *Sauromalus varius* covering a decade of captive breeding

Sauromalus varius, the Piebald chuckwalla, is endemic to Isla San Esteban in the Sea of Cortez. This large iguanid was listed as CITES I endangered in 1981 and in an effort to protect this species several individuals were collected for a captive breeding colony located at the Arizona Sonora Desert Museum in Tucson, Arizona. There have been few studies examining the effectiveness of this colony on maintaining genetic diversity within the group. In 1993 L. D. Densmore collected blood from every individual located in the colony at that time. In 2004 blood was again collected from all individuals located in the colony. This temporal separation of samples provides us with the unique ability to examine the effects a decade of captive breeding have had on this endangered species. We have chosen to utilize eight microsatellite loci to examine those effects by determining genetic diversity, inbreeding, and overall effectiveness of the program at maintaining genetic diversity. Results for these loci are compared to results from sixteen individuals wild caught in 1993.

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Validated age and growth of the Sandbar Shark, *Carcharhinus plumbeus*, (Nardo, 1827) in western Australian waters

Age and growth of the sandbar shark, *Carcharhinus plumbeus*, were examined using vertebral ageing techniques and tag-recapture data. Growth curves were derived from consensus counts by three readers of growth-bands from the vertebrae of 238 individuals, ranging in size between 47 and 154cm FL. The annual periodicity of growth-band formation was validated using vertebrae from tagged sharks injected with oxytetracycline ($n=10$) and calcein ($n=25$), at liberty for between 31 and 2,723 days. The oldest female was 25 years and the oldest male was 19 years. The ages at which 50% of female and male sharks were mature were estimated to be 16 years and 14 years, respectively. Growth increment data from 95 tagged *C. plumbeus*, at liberty for between 1 and 2,723 days, were used to construct growth curves for comparison with those derived by vertebral analysis. The two methods yielded noticeably different results. Based on a known size at birth of 42.5cm FL, von Bertalanffy parameters estimated using length at age data from vertebral analysis were: $K= 0.039 \text{ yr}^{-1}$ and $L_{\infty}= 245.8 \text{ cm}$; $K= 0.044 \text{ yr}^{-1}$ and $L_{\infty}= 226.3 \text{ cm}$ and $K= 0.040 \text{ yr}^{-1}$ and $L_{\infty}= 239.6 \text{ cm}$ for females, males and combined sexes, respectively. The von Bertalanffy parameters derived from tag-recapture data were: $K= 0.169 \text{ yr}^{-1}$ and $L_{\infty}= 134.9 \text{ cm}$ for combined sexes. As the growth parameters estimated from tag recapture data were biologically unrealistic, the results from vertebral ageing were determined to provide a more accurate description of age and growth in this study. These results confirm that *C. plumbeus* is a slow-growing and late maturing species that is vulnerable to overfishing and would take considerable time to recover from overexploitation. These results will provide the basis for detailed age-structured stock assessments that will be used in developing management strategies for the fisheries that target this stock.

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The effect of paraquat on the antioxidant defense system of the American Bullfrog (*Rana catesbeiana*)

Commercially purchased bullfrog tadpoles (*Rana catesbeiana*, Gosner Stage 36-37) were subjected to 0 (control), 0.1, 0.5, 1.0, and 2.0 mg/L paraquat for 24 hours. Liver and muscle (tail clip) tissues were removed and analyzed for catalase, superoxide dismutase (SOD), general peroxidase, and glutathione reductase (GR) activities. In the controls, there was no significant difference in GR activity in tissues collected from the liver and the tail; however, peroxidase, SOD, and catalase activities ranged from 2- to 20-fold higher in the liver than in the muscle tissue. Treatment with paraquat resulted in significant increases in SOD, general peroxidase, and GR activities in the liver tissue, while the high constitutively expressed catalase activity remained unchanged. GR activity also increased significantly in the muscle tissue when the tadpoles were treated with 2 mg/L paraquat, but the activities of the other three antioxidant enzymes did not vary significantly from the control values in this tissue regardless of the paraquat treatment. After 24 hours of paraquat treatment, all tadpoles at all treatment levels were alive and appeared to be vigorous, suggesting that the bullfrog is very tolerant to paraquat toxicity. It is proposed that this tolerance is due to the stress-induced increases in the activities of antioxidant enzymes such as SOD, general peroxidases, and GR and high constitutive activity of catalase.

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The decline of natural history study in herpetology: An analysis of historical publication patterns in two herpetology journals

Both traditional and contemporary natural history studies provide important information regarding the life histories of amphibians and reptiles. The number of investigators working in natural history is reported to have gradually declined over recent decades. This study compares publication patterns between *Herpetologica* and *Journal of Herpetology* in an attempt to reveal how the numbers of natural history publications have varied over the lives of these two journals. The number of articles and natural history articles was tabulated in each issue. These data were analyzed using trends analysis and the individual trends were analyzed using regression techniques to describe changes in publication frequency. Publication of natural history articles increased from 1936 through the 1960s; however, these manuscripts were dominated by small notes and isolated observations. In *Herpetologica*, both the number of total publications and of natural history publications remained stable through the late 1960s. Although the total number of articles published in *Herpetologica* has declined, the relative number of publications related to the life histories of amphibians and reptiles has dropped much faster. Both the numbers of natural history articles and all articles have increased since the founding of *Journal of Herpetology*; however, natural history publishing has dropped substantially since the mid 1990s. When

combining publishing trends for both journals, there was an obvious decrease in the proportion of articles devoted to or involving natural history. The likely explanations for these reductions are complex but may include reductions in grant funding, editorial decisions, additional competition from similar journals, and the rise of molecular biology.

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A comparison of herpetofauna communities in three northwestern Louisiana wildlife management areas

Herein we describe the herpetofauna present on three wildlife management areas in northwestern Louisiana. The three WMAs include Jackson-Bienville WMA (Jackson & Bienville Parishes), Loggy Bayou WMA (Bossier Parish), and Bayou Pierre WMA (Red River Parish). Study areas were inventoried from Spring 2004 through Spring 2005 using time-area point surveys. All points were documented using a Trimble Geoexplorer XT global positioning systems unit. Habitat characteristics were recorded photographically and quantitatively. We present various new species records for some of the counties and describe the herpetofauna trophic guilds present at these management areas. The data within represent the first records for herpetofauna at any of these three WMAs.

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Comparative thyroid hormone concentration in maternal serum and yolk of the bonnethead shark (*Sphyrna tiburo*)

Hormones are chemical messages within the body that can produce and coordinate anatomical, physiological, and behavioral changes within an animal. In mammals, thyroid hormone regulates the basal metabolic rate, initiates differentiation of the central nervous system, and is vital to successful early development. As in mammals, thyroid hormone has been found to regulate growth and development in teleost fish, however, its role within cartilaginous fish is poorly understood. This study examined the presence of thyroid hormone in the maternal serum and egg yolk of developing bonnethead sharks, (*Sphyrna tiburo*), within two sites along the Florida coast. Samples were taken during different developmental periods, including pre-ovulatory, post-ovulatory, and yolk-dependent stages in order to establish a developmental profile of thyroid hormone. The concentration of thyroid hormone increased as development proceeded which is similar to the pattern seen in yolk of teleosts, avians and reptiles. Histological assessments were made on the embryonic thyroid gland to determine if embryos were capable of endogenous thyroid hormone production. Embryos that were greater than 5.9 cm in total length did have thyroid follicles

that possessed characteristics of active secretion. The concentrations of thyroid hormone within yolk and serum were found to differ within developmental periods as well as within sites. The concentration of thyroid hormone was highest in the area that supported higher growth rates, and size at maturity, which suggests possible plasticity in maternal provisioning.

***MCCOY, A. JEANENE; CORWIN, ALLISON L.; STAMPER, M. ANDREW**

The Living Seas, Epcot®, Walt Disney World® Resort, 2016 N. Avenue of the Stars, EC-Trl W-251, Lake Buena Vista, FL 32830, USA

Behavioral observations on captive sandtiger sharks, *Carcharias taurus*, at The Living Seas

The object of this study was to determine baseline behaviors of captive sandtiger sharks, *Carcharias taurus*, inhabiting the 21.5 million-liter saltwater environment of The Living Seas. Concurrently, the presence of scuba divers was also evaluated for its effect on these behaviors. After their introduction, two female sharks were simultaneously observed for 6 weeks, under five different scuba diving conditions: (1) no divers, (2) three divers, (3) six divers with food present, (4) three staff divers and 12 guest snorkelers, and (5) three staff divers and 12 guest scuba divers. Each shark was observed for a total of sixty, 30-minute sessions. A total of 22, species-typical, motor patterns and postures were recorded during the study. Three additional behaviors were observed outside of sessions. Overall, a solitary behavioral pattern was seen for each animal, swimming on average 91.7% of their time alone in a relatively "straight line" pattern. Conversely, during intra-species interactions, a dominance relationship was suggested between the two sharks. Dominance was inferred by one animal yielding when the two animals passed each other, and "tailing," characterized by closely following and restricting the tail movement of the lead shark. Site fidelity was observed for both sharks, spending 68.8% of their time in two of the nine defined areas within the environment, which coincided with feed location. During guest dive programs, however, the sharks were observed utilizing other areas of the environment more often. Other behaviors influenced by the presence of divers include the sharks' activity levels and behavioral range and frequency. This study provided descriptive techniques to determine basic behaviors of sandtiger sharks in a captive environment and assessed the effects of divers within the habitat on the behavior of the sharks.

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The Living Seas, Epcot®, Walt Disney World® Resort, Lake Buena Vista, FL 32830, USA

Behavior of spotted eagle rays, *Aetobatus narinari*, in captivity at The Living Seas

Although commonly found throughout the coastal surface waters of the world's warm and tropical oceans, limited information is available on the behavior and ecology of spotted eagle rays (*Aetobatus narinari*). This study focused on

describing and quantifying species-typical motor patterns and postures of 3.1 spotted eagle rays in a 21.5 million liter, semi-natural display aquarium at The Living Seas. Study subjects were two adult rays, one male and one female, measuring \approx 1.2 meters in disc width. A total of 81 hours of data (40.5 hours/ray) were collected during five, two-week sessions occurring between January and December 2002. Rays were observed simultaneously by divers for 30-minute periods, once per day. Occurrence and frequency of behaviors, as defined on a pre-established ethogram, were recorded. Additionally, vertical and horizontal positions were also recorded at timed intervals enable to establish space use patterns. An additional 10 hours of observations were made during the introduction of two juvenile males. Out of the 21 behaviors defined by the final ethogram (7 states and 14 events), 18 behaviors were recorded during the study with the three remaining behaviors observed outside of sessions. The average specific duration (in seconds) of 11 of the 18 behaviors was also determined. Behavior varied between the rays and by season. The rays spent an average of 67.7% of their time alone; swimming in a baseline pattern (sustained, relaxed forward movement), and conversely spending an average of 24.7% of their time within 3 meters of another spotted eagle ray. Analysis on spatial usage of the environment indicated that one of the nine spatially defined areas was utilized significantly more than other areas (34.8%, $p < 0.05$). However, space use varied by ray, time of day, and time of year. These observations expand the previous repertoire of behaviors in spotted eagle rays. Future studies will evaluate the social significance of these findings.

***MCCOY, MICHAEL W.; BOLKER, BENJAMIN M.**

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Quantifying the effect of prey density on induced defenses in pine woods treefrogs

Tadpoles of many anuran species can adjust their morphology and behavior in response to predators and many studies have investigated the role of these trait changes in species interactions. Predator induced changes in prey morphology are one type of trait change that has recently received a lot of attention in the ecological literature. However, we still do not have a good understanding of how sensitive tadpoles are to changes in their threat environment and whether they modulate the magnitude of their phenotypic response appropriately. If a predators foraging capacity is limited (i.e. Type II functional response) then the per capita risk of predation should decrease as density of alternative prey increases. Thus, prey species may perceive the relative risk of being eaten to be lower as the density of alternative prey increases. In this talk, we discuss an experiment that tests whether density affects the magnitude of morphological responses of tadpoles to the threat of predation. We also discuss an analytical approach for analyzing morphological plasticity data that allows us to estimate trait change and evaluate the relative strengths of main effects and interactions on overall morphological changes. We find that tadpoles respond less strongly to the presence of predators when housed at high conspecific density than when housed at low conspecific density.

***MCDONALD, ELIZABETH; FORDYCE, JAMES; MARION, ZACHARY**

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Inducibility of bufadienolides in adult American toads, *Bufo americanus*

The phenomenon of induced responses, phenotypic changes following exposure to a real or perceived stressor, has been repeatedly observed in plant-herbivore systems. However, very few examples of inducible responses have been documented in vertebrates. Although the threat of predators induces a wide variety of plastic responses by larval anurans, including changes in morphology, behavior, and the timing of life history stages, the possible inducibility of chemical defenses has not been examined for adults. Prior research suggests that postmetamorphic toads exposed to predator cues during their larval stage had significantly higher levels of chemical defense compounds (bufadienolides) than toads lacking this exposure. Our primary goal was to determine whether qualitative or quantitative changes in the chemical components of the parotid secretion are inducible in adult American toads (*Bufo americanus*). By subjecting toads to differing levels of forced secretion expression and by quantifying the bufadienolide concentrations in the secretions, we were able to identify changes in the parotid toxin profile between the treatment groups and quantify individual variation in toxin profiles. We will address these specific questions: is there a quantitative difference in the total amount of bufadienolide present between sampling periods for each treatment group, and is there a qualitative difference in the relative amounts of the different bufadienolides between sampling periods for each treatment group? Preliminary data suggest that toads that were expressed frequently show a decrease in the total bufadienolide content and the number of bufadienolides present in their secretions compared to control animals.

***MCDONOUGH-HAUGHEY, CHRISTIN; PATON, PETER W. C.**

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Dispersal ecology of radio-tagged adult spotted salamanders on a golf course

We investigated dispersal ecology of adult spotted salamanders (*Ambystoma maculatum*) in forested landscape fragmented by a golf course. Past research found that adult spotted salamanders migrate an average of 168 m from breeding ponds and open habitats may represent dispersal barriers. However, a recent study found that spotted salamanders may migrate successfully across fairways. Using radio telemetry, we (a) examined dispersal distances from breeding ponds; (b) developed resource selection functions for micro- and meso-habitats, based on an analysis of animal locations and random points; and (c) quantified the effects of habitat fragmentation by golf course fairways on spotted salamander migratory behavior. We monitored the migration ecology of 80 radio-tagged adult spotted salamanders at Lake of Isles Golf Course, CT from March through December 2004. Animals were tracked as they emigrated from three ponds surrounded by fairways and a control pond surrounded by contiguous forest.

Contrary to past research, adult salamanders often dispersed across fairways. Migration distances were over twice as far as published estimates. Salamanders emigrated farther across fairways (mean = 150 m, range 13 to 417 m) than contiguous forests (mean = 100 m, range 20 to 180 m). Females (mean = 175 m, range 21 to 417 m) dispersed farther than males (mean = 110 m, range 13 to 355 m). Radio-tagged salamanders selected microhabitats with a high density of small mammal burrows, where they were generally detected 1 to 40 cm deep. Eastern garter snakes (*Thamnophis sirtalis*) were the primary mortality factor for dispersing animals on the golf course, with 12% (7 of 57) of radio-tagged salamanders consumed by garter snakes. No animals at the control pond were consumed by snakes. Our research suggests that golf courses need to be designed and managed correctly to provide viable habitat for spotted salamanders.

***MCELROY, W. DAVID; MCCANDLESS, CAMILLA T.; KOHLER, NANCY E.; WETHERBEE, BRADLEY M.; DUFFY, KATHLEEN A.; RECKSIEK, CONRAD W.**

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Diet, gastric evacuation, and feeding ecology of juvenile sandbar sharks, *Carcharhinus plumbeus*, and smooth dogfish, *Mustelus canis*, in Delaware Bay

Sandbar shark (*Carcharhinus plumbeus*) and smooth dogfish (*Mustelus canis*) are common coastal shark species along the U.S. Atlantic coast. Both species use coastal estuaries as nursery areas, and Delaware Bay is one of the largest nursery areas for both species along the U.S. east coast. This study characterizes the diet of sandbar and smooth dogfish sharks in the Delaware Bay nursery. Sharks were caught using bottom longlines and gillnets at locations throughout the bay. Stomachs were everted and contents were collected using non-lethal techniques. Stomach contents were weighed and identified to the lowest taxon possible. A total of 217 smooth dogfish was sampled, with stomachs of 212 (97.7%) sharks containing food. Weight of stomach contents represented a mean of 1.29% of their body weight (%BW). Smooth dogfish in Delaware Bay consumed mostly crustaceans (82% based on index of relative importance - IRI), followed by molluscs (11% IRI), and smaller quantities of annelids, and teleosts. The dominant crustaceans were a variety of crabs, with Majid and Cancrid occurring most frequently, and Portunid and Pagurid crabs also common. Changes in the diet with ontogeny were observed, with annelids, shrimp, and molluscs (primarily razor clams), occurring more frequently in stomachs of younger sharks. Larger smooth dogfish consumed larger prey and had a more diverse diet that included several teleost species. For sandbar sharks, 441 of 822 (53.7%) stomachs examined contained prey items. The mean quantity of food present in stomachs of sandbar sharks represented 0.51% BW. The diet of sandbar sharks was dominated by teleosts (78% IRI), followed by crabs (22% IRI). The teleost component of the sandbar shark diet contained many benthic, but few pelagic species. This study represents a portion of a project on the feeding ecology of

these sharks in Delaware Bay, which will include measures of gastric evacuation and estimates of daily ration for these two species. **AES GRUBER**

***MCGARRITY, MONICA E.; MILTON, SARAH L.**

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Stress protein expression in green turtle fibropapillomatosis: Evaluating health and stress levels in marine turtles

Green turtle fibropapillomatosis, first described in *Chelonia mydas* in 1938, has since been diagnosed in virtually all species of marine turtles. This disease, characterized by the proliferation of highly debilitating benign tumors that primarily affect juvenile turtles, has reached almost epidemic proportions worldwide. Although a herpes-like viral agent has been suggested, the etiology of this disease is as yet uncertain, and is likely multifactorial in nature. Studies have indeed shown an association between fibropapillomatosis and juvenile developmental habitats in areas of high anthropogenic disturbance. In addition, turtles in these disturbed areas, even those without visible tumors, have been shown to be chronically stressed and immunosuppressed. Recently, there has been considerable interest in the identification of molecular markers indicative of both general and specific stressors in a wide variety of aquatic and terrestrial organisms. One group of such potential markers, the heat shock or stress proteins, are expressed in response to a wide variety of environmental and physiological stressors, including viral infections and tumors. This study examines stress protein expression in both healthy and fibropapilloma afflicted green (*Chelonia mydas*) and healthy loggerhead (*Caretta caretta*) turtles from a highly stressed environment (Indian River Lagoon, FL) with a high incidence of fibropapilloma disease and compares this response to that of individuals from a relatively pristine environment (Trident Basin, Port Canaveral, FL). Finally, this study investigates the tissue specific expression of these stress proteins, which may provide valuable insights into the treatment of this devastating disease.

MCGRATH, PATRICK E.

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Site fidelity and tidal movements of White Perch (*Morone americana*)

White perch (*Morone americana*) is one the most common species residing in the brackish tributaries of the Chesapeake Bay. White perch is a commonly sought after commercial and recreational species and is one of the few species that are permanent residents in the Bay. There is very little known about their site fidelity, home range, or tidal interactions. This acoustic tagging study examined fifteen white perch residing in two small tributaries of the York River. White perch exhibited a high degree of site fidelity along with a small home range. The fixed kernel method was utilized to measure home range size. The output contours considered were the 95% contour (total home range) and the 50% contour (core area of activity). The kernel method areas were .0128 sq. km. and .0021 sq. km., respectively. White perch typically had two core areas of activity

which often correlated to the tidal stage. They were often found during high tide upon the flooded marsh or up in shallow creeks and in the relatively deep main channels during low tide. White perch did not show any movement with sudden changes in salinity and/or temperature resulting from tropical storms or Hurricane Isabel. **STOYE ECOLOGY & ETHOLOGY**

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Seaward migration of larval anadromous gobies in Hawaii: Temporal patterns and conservation implications.

The gobioid fishes that are native to Hawaii's streams and rivers are all amphidromous, and as such, have a pelagic marine larval stage. After hatching, goby free-embryos must migrate from instream hatching sites to oceanic feeding sites quickly to avoid starving to death. Relatively little information is available on the spatial and temporal patterns in this critical seaward migration for Hawaii's amphidromous gobies. Stationary drift nets were used to identify diel and lunar temporal patterns in the downstream drift of newly hatched *Lentipes concolor*, a sicydiine goby that frequently lives in high-elevation stream reaches. Seaward migration of free-embryos peaked during the three hours following sunset, and was generally higher during new moon phases. These adaptations may decrease susceptibility of larvae to predation by visually-oriented larvivorous fishes that abound in nearshore marine environments in Hawaii. A clearer understanding of this seaward migration of newly hatched free-embryos is critical for the effective conservation of amphidromous fishes. This is especially true for species that have local populations of adults that spawn in headwater stream reaches far from the mouth of the stream.

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Factors affecting among annual variation in incidence of multiple paternity in common snapping turtles (*Chelydra serpentina*)

Multiple paternity can affect the reproductive success of males and females. Females may benefit through increased genetic variability or quality of offspring. Male reproductive success is also affected as a function of the number of successful matings and proportions of offspring in each clutch sired. Mating success and incidence of multiple paternity may also be related to the size or age structure and adult sex ratios present within a marsh. Common snapping turtle (*Chelydra serpentina*) males are territorial and are larger than females, suggesting size-based variance in male reproductive success and incidence of multiple paternity. In females there is a strong correlation between clutch size and body size. Therefore, larger and potentially older females are of higher quality than

smaller females, and are likely to be mated by multiple males. Alternatively, marsh size, the number of territory holding males, and their residence time may also influence the frequency of multiple paternity. Long-term mark recapture studies on the Edwin S. George Reserve in Pinckney, Michigan allow analyses of individual males and females of known age, known area of residence, and previous reproductive history. Using microsatellites, we examined offspring in 40 clutches for evidence of multiple paternity. The frequency of multiple paternity was highly variable among years (20% to 67%), but the annual variation was consistent across marshes. Clutches from 60% of females sampled in multiple years exhibited single paternity in one year and multiple paternity in a subsequent year. Relationships between incidence of multiple paternity, female size, clutch size, and characteristics of marshes that affect movements and encounter probabilities will be discussed.

MEANS, D. BRUCE

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Effects of rattlesnake roundups on the Eastern Diamondback Rattlesnake, *Crotalus adamanteus*

Data for total number of snakes and largest snakes by weight were gathered from official roundup records and newspaper accounts for eastern diamondback rattlesnake roundups held in Opp, AL, and Whigham, Fitzgerald, and Claxton, GA. Statistical analyses revealed two patterns among the Georgia roundups: 1) annual numbers of snakes were erratic but all three roundups experienced their largest takes between about 1983 and 1993; 2) following about 1993, all three roundups experienced a marked decline in the sizes of the largest rattlesnakes (up to 35% in body weight) brought in annually. Newspaper quotes of roundup officials indicate that local rattlesnake populations declined drastically after only a few years and necessitated expansion of hunting activities into other Georgia counties and into Florida. The decline in body size takes place after about 20 years of roundup operation and means that older, mature snakes are becoming scarce since size is correlated with age. This has serious population consequences in a long-lived, iteroparous species whose females take three years or more to reach maturity and that bear young every two or three years.

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Diet and three-dimensional morphology: An experimental analysis of carapace form in the Yellow Spotted Amazon River Turtle (*Podocnemis unifilis*).

The three-dimensional form of the carapace has profound implications for performance in aquatic turtles. Consequently, factors affecting the morphology of the carapace may ultimately affect survival by impacting hydrodynamic streamlining (particularly important to highly aquatic species), structural integrity, and other properties. In order to examine the possible effects of diet on carapace morphology, we reared the members of a clutch of *Podocnemis unifilis*, the Yellow-Spotted Amazon River Turtle, using three different dietary regimes (high protein, wild type, and commercial). Longitudinal, three-dimensional coordinate data were collected for each specimen over a one-year period using a novel molding compound and subsequent resin casting. Morphological differences among treatment groups were evident after only a short duration of dietary divergence. Specifically, the relative growth of marginal and costal scutes showed significant variation among the three groups. The sample fed on a high protein diet grew significantly less than either of the other two samples and exhibits a more divergent overall morphology. The results of this research suggest that local dietary differences at the margins of species ranges may affect morphology and performance. Consequently, novel epigenetic morphologies may accumulate by natural selection in localized areas or new habitats. Thus such epigenetic variation may act to reinforce to habitat specificity and so a precursor to speciation.

***MEISCHKE, LARA; CRAMB, GORDON**

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An extremely tolerant shark: Osmoregulation in the bull shark, *Carcharhinus leucas*

The bull shark, *Carcharhinus leucas*, is a true champion of salinity tolerance. It can survive in water ranging from 0 to 53 ppt by precisely controlling the composition of its body fluids. This is achieved by the expression, function and coordination of several ion transporters and channels including the Na, K-ATPase. Bull shark Na, K-ATPase alpha and beta subunit isoforms have been amplified, cloned and sequenced. Northern blotting has been used to quantify messenger RNA expression in the rectal gland, gill, kidney and intestine of both FW- and SW-acclimated sharks. Using antibodies raised to the known sequences of both subunits, protein expression of Na, K-ATPase alpha and beta subunits have been compared in the gill, kidney and intestine. In addition,

immunohistochemistry has been used to show the distribution of Na, K-ATPase within the osmoregulatory tissues. **AES GRUBER**

***MEISTER, H. SCOTT; SEDBERRY, GEORGE R.; MCGOVERN, JOHN C.; WYANSKI, DAVID M.; HARRIS, PATRICK J.**

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Results of a tag and recapture study of gag, *Mycteroperca microlepis*, and greater amberjack, *Seriola dumerili*, along the southeastern U.S.

During 1995-1999, 3,876 gag, *Mycteroperca microlepis*, and 2,392 greater amberjack, *Seriola dumerili*, were conventionally tagged off the southeastern United States from North Carolina to southern Florida. Prior to release, the swim bladder of tagged fish was deflated using a 16-gauge hypodermic needle. Approximately 11% of the gag and 16% of the greater amberjack were recaptured. Many gag (36%) and greater amberjack (35%) moved < 2 km, however, 23% of the recaptured gag and 30% of the recaptured greater amberjack moved > 185 km. Most gag and greater amberjack that moved > 185 km were tagged off South Carolina and recaptured off Georgia, Florida and in the Gulf of Mexico. Recapture rate of gag declined with increasing capture depth while the recapture rate of greater amberjack showed no relation to depth of capture. Gag tagged at 20-40 m showed the greatest degree of movement while gag tagged in deeper water appeared to be relatively sedentary and larger in size. Movement of greater amberjack was not found to be related to depth. Depth related mortality of degassed gag was estimated to range from 14% at 15 m to 95% at 95 m. Gag and greater amberjack are capable of extensive movement, and genetic exchange between the Atlantic and Gulf of Mexico has been found for these species. Currently different management plans are in place for both gag and greater amberjack in the Atlantic and Gulf of Mexico.

MELO, MARCELO R.S.

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Deep-sea anguilliforms and saccopharyngiforms (Osteichthyes: Elopomorpha) collected on the Brazilian continental slope between 11° and 23° South

New representative material of pelagic and demersal deep-sea fishes obtained in the Brazilian continental slope revealed an extraordinary diversity of Anguilliformes and Saccopharyngiformes in the Western South Atlantic (WSA) previously undetected. The specimens were collected by the French R/Vs *Thalassa* and *Marion Dufresne*, and by the Brazilian R/V *Astro Garoupa* between 11° - 22° S, in depths from 200 to 3,450 m. Thirty one species included in eight families were identified and are listed below; ten species (32%) were previously known from elsewhere, but had never been recorded before in the WSA (indicated with an asterisk); a new synphobranchid eel was identified; and another four need further investigation. *Colocongridae: Coloconger meadi**;

Congridae: *Ariosoma* sp.1, *A. sp.2*, *Acromycter atlanticus**, *A. perturbator*, *Bathyroconger vicinus**, *Pseudophichthys splendens*, *Bathycongrus vicinalis**, *Xenomystax congroides**; Nemichthyidae: *Avocettina infans*, *Nemichthys scolopaceus*; Nettastomatidae: *Hoplunnis similis**, *Nettastoma melanurum*, *Venefica* sp. 1, *V. sp. 2*, *V. procerata**; Serrivomeridae: *Serrivomer schmidti*, and *Stemonidium hypomelas*; Synaphobranchidae: *Atractodenchelys cf. prhix**; *Diastobranchnus capensis*; *Dysommnia rugosa*; *Histiobranchnus cf. australis**; *Ilyophis blachei*, *I. brunneus*, *Simenchelys parasitica*, *Synaphobranchus affinis**, *S. brevidorsalis*, *S. oregoni*, and *Synaphobranchus* sp. n.; Eurypharyngidae: *Eurypharynx pelecyanoides*; and Cyematidae: *Cyema atrum*. With the exception of *H. cf. australis*, *I. blachei* and *Synaphobranchus* sp. n., all the other species were previously recorded in the Western North Atlantic, suggesting a strong zoogeographical affinity with that region. Regarding their vertical pattern of distribution along the slope, four zones were recognized, the Lower Shelf (to 500 meters depth), Upper Bathyal Slope (500 to 750 meters), Lower Bathyal Slope (from 750 to at least 2,125 m) and the Abyssal Zone (a single specimen collected at 3,450 m).

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Freshwater stingrays fisheries (Chondrichthyes: Potamotrygonidae) at black and clear water river systems in the Brazilian Amazon

Potamotrygonids are elasmobranchs that exhibit the same complexity of life cycle as marine elasmobranchs. Freshwater stingrays presently are not among the main target species for the ornamental fish industry, and until recently, neither for the commercial fishery fleet in the Brazilian Amazon region. In the last two years this picture is changing and at least frozen meat of two species of freshwater stingrays *Paratrygon aiereba* and *Potamotrygon motoro* has become common in some specialized fish market in Amazonas and Pará State. In both ornamental and commercial fisheries, fishing trips in two different rivers systems (Rio Tapajós Basin and Rio Negro Basin) were conducted in collaboration with local fishermen during the fishing season to obtain capture and effort data. *Potamotrygon motoro* is the only species common in both fisheries activities. CPUE of this species to ornamental fishing at Rio Negro Basin (black water river system) has not been decline in the last 06 years. The CPUE has been around 16,36 individuals/fishermen/year (s.e \pm 5, 3). In the last two years in Rio Negro basin, the rising of fishing effort to artisanal fisheries for food purpose using hook and line is causing a decline of individuals of high classes of disc width from 70 cm to 65,0 cm. The stingray in this kind of fishing is mutilated and discarded. At Rio Tapajós Basin, *P. motoro* is being fishing as target species to artisanal fisheries for food purpose using hook and line. The fleet is new and probably will grow in the future years, because the traditional stocks of teleosts fishes are collapsing in the area.

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Australian agamid lizards: An insight into evolutionary relationships and ecological diversification within Amphibolurinae

In Australia more than 66 species of Agamid lizards are currently recognized and are known as the sub-family Amphibolurinae, which is genetically distinct from other agamid clades. Amphibolurinae has diversified extensively within Australia, occurring in a wide variety of habitats, ranging from tropical rainforests to deserts and even sub-alpine highlands. An analysis of morphological characteristics of the major clades within Agamidae indicates that Amphibolurinae is an adaptive radiation or a clade that exhibits unusually great divergence into a variety of adaptive forms. Unfortunately, more extensive analyses of the evolution of morphological and ecological form in this group is hampered by unresolved phylogenetic relationships both within and between species. Thus, we have undertaken to resolve these uncertainties using DNA sequencing across all species. Adding to previous work, we have sequenced approximately 160 individuals that incorporate 85 species and sub-species, using both mitochondrial and nuclear regions. Currently, we are focusing on evolutionary relationships within and between species in two of the largest genera, *Tympanocryptis* and *Ctenophorus*. We have found that the current number of recognized taxa significantly underestimates the level of genetic, morphological and ecological diversification within these genera. We will be presenting results of genetic analyses that indicate that extensive revision of the current taxonomy of Amphibolurinae is required.

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Global amphibian extinctions and policy shift in conservation actions

Researchers spent the decade of the 1990s establishing that amphibian declines were real, identifying causal agents, and documenting extinctions of numerous species. A series of recent papers brings us to the realization that we have underestimated the geographic and taxonomic extent of the crisis, the fungal pathogen (*Batrachochytrium dendrobatidis*) cannot be stopped, and that traditional conservation actions are insufficient. While zoos have traditionally been charged with conservation of critically endangered species, many regulatory policies and logistical constraints will hamper this route in the case of amphibians. Thus, to conserve some portion of amphibian biodiversity, we must develop and implement novel strategies that break down or avoid traditional barriers among nations, academic disciplines, government agencies, zoological parks, and private individuals. We must do so quickly, both in response to sites affected by chytridiomycosis, and in anticipation of its arrival at new sites. We present some ethical, biological, and practical considerations involved in protecting global amphibian biodiversity in the face of the continued spread of this emerging

infectious disease.

***MENDONÇA, M.T.; WARD, C.K.**

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Latitudinal differences in stress responsiveness in anurans: Preliminary evidence

Tropical vertebrates generally exhibit a different suite of life history traits from their temperate counterparts. Additionally, there are physiological traits that also exhibit a latitudinal cline. For example, tropical birds and mammals have long been documented as having lower basal metabolic rates than the temperate counterparts. Basal testosterone and corticosterone levels have also been shown to be lower in tropical vs. temperate birds. It is hypothesized that, due to the high parasite load in the tropics, tropical species would maintain low levels of hormones that might act in an immunosuppressive manner (i.e. corticosterone and testosterone). In a survey of existing metabolic literature on anurans, we found that tropical frogs and toads (38 species, 8 families) also exhibit significantly ($p < 0.03$) lower standard metabolic rates than temperate species (47 species, 7 families). To test whether tropical anurans also exhibited low baseline and maximal levels of corticosterone, we collected blood immediately upon capture from a variety of species from temperate (South Carolina and Alabama) and tropical (Costa Rica) areas. We then challenged these animals with saline or a high dose (100 ng/g BWT) of ACTH (adrenocorticotropin hormone), which should stimulate a maximum corticosterone response, and collected blood 4 hours after injection. We found that the tropical anurans sampled ($n=6$ species) displayed much lower baseline corticosterone levels than their temperature counterparts and they did not exhibit a significant increase in corticosterone in response to ACTH challenge ($n=4$ species). Although these data are preliminary (i.e. few species with small sample sizes/species), they support the hypothesis that tropical animals would display levels of a potentially immunosuppressive steroid hormone.

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Post-breeding spatial ecology of male *Rana sylvatica*

Spatial studies provide insight into how organisms are adapted to environmental and habitat conditions. Migration paths and habitats of occurrence are well studied in frogs but little is known about activity and movement patterns during foraging or after breeding events specifically because of their small size and cryptic nature. The Wood Frog (*Rana sylvatica*) has been reported to move large distances to breeding sites and then disperse into upland forests to forage in the leaf litter. Whereas large numbers are encountered during breeding, its cryptic

nature makes encounters rare outside of the breeding period. Our objectives were to determine where males dispersed to after breeding and if male body size related to distance traveled and home range size. We measured body size and radio-equipped nine adult male *R. sylvatica* from an upland forest in east central Illinois and located them from 3-March-2004 until 18-March-2004. Only six frogs were used in the analysis because one shed the transmitter and two had too few movements for analysis. Our results indicate smaller and lighter frogs moved greater distances and had larger home ranges; however we lack the sufficient power for these conclusions to be conclusive.

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Ontogenetic variation in the bufadienolides of the toads, *Bufo americanus* and *Bufo fowleri*

Bufadienolides are presumed to be important anti-predatory compounds in bufonid toads although much of their chemical ecology and ontogeny are poorly understood. Ontogenetic variation in bufadienolides in toads of all developmental stages (eggs to adults) was assessed by HPLC. For adults, parotoid gland secretions were analyzed and for earlier developmental stages (eggs to newly transformed individuals) entire toads were analyzed. Results showed variability in numbers and concentrations of bufadienolides among toad developmental stages in both species. A total of ten bufadienolides was detected in developing toads (nine in *Bufo americanus* and five in *Bufo fowleri*). Average total concentrations of bufadienolides in developing toads were 1.19 and 1.44 ng/g dry weight for *B. americanus* and *B. fowleri* respectively. The majority (83 percent) of individuals possessed no detectable bufadienolides. *Bufo fowleri* eggs had statistically larger concentrations of bufadienolides than did *B. americanus* eggs suggesting possible differences in parental investment. Bufadienolide concentrations across developmental stages appeared to fit the predictions of Brodie and Formanowicz's (1987) model to some extent, but were more pronounced in eggs and nearly undetectable in metamorphs and transformed individuals. More bufadienolides were detected in adult toads than in pre-metamorphic and newly transformed toads (30 versus 10). In adults, *B. americanus* had more bufadienolides than *B. fowleri* but mean total concentrations were similar (46.03 and 34.63 ng bufadienolide/ug dry parotoid secretion respectively). Concentrations of 12 bufadienolides were used in a PCA to investigate variability between toad species and among habitats. In *B. americanus* there was much overlap in bufadienolide concentrations from all collection sites. Overall, results suggest that the larger distribution of *B. americanus* in Michigan could be attributed to differences in bufadienolide composition between species. Finally, the relative contribution of bufadienolides to unpalatability was suggested but remains a hypothesis to be tested. **SSAR SEIBERT ECOLOGY**

MESHAKA, JR., WALTER E.

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The snake assemblages of Allegheny grasslands in western Pennsylvania

During September 2002-October 2004 snakes were individually marked and released at three Allegheny grassland sites at the Powdermill Nature Reserve in Westmoreland County in western Pennsylvania. I asked the questions, what species of snakes live in various grassland habitats of western Pennsylvania and in what proportions are these snakes found in those grasslands? I marked individuals of seven species of snakes. Although the species varied with respect to the resident species, at all sites the snake assemblage was uneven and dominated by the Eastern garter snake (*Thamnophis sirtalis sirtalis*). A common habitat of the Northeast and Pennsylvania grasslands are being lost through forestation and development. I propose that the preponderance of garter snakes reflects a response to the concentration of its predator, the northern black racer (*Coluber constrictor constrictor*), in these patches of diminishing size.

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Florida's runaway exotic train

Forty-four species of exotic amphibians and reptiles are established in Florida. The pattern common to most of them is a southern Florida concentration of pet trade-related introductions of small-bodied early-rapidly-reproductive voracious species, whose continued introductions have yet to abate. Most of the species are lizards. Collectively, the exotic herpetofauna of Florida represents a human-caused runaway train. In an information presently known, I proffer a solution to this pressing conservation issue and a framework for gathering the sorts of information useful in the endeavor of colonization theory and effective species management.

MEHTA, RITA S.

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Comparative epaxial motor patterns in snakes during constriction

Constriction as a prey-handling method was associated with the adaptive radiation of snakes and is a behavioral homology for the majority of snake taxa. Constriction postures vary among lineages, but phylogenetic variation in the epaxial motor patterns underlying constriction remains unknown. I studied the postures and epaxial muscle activity patterns of constriction in a basal snake (*Loxocemus bicolor*) and two intermediate snakes (*Python molurus* and *Boa constrictor*). With my results, and those published previously for a more derived snake (*Pituophis melanoleucus*), I test whether the variation in constriction behavior corresponds with the underlying epaxial motor patterns. In my

experiments, five individuals of *L. bicolor* used lateral bends to coil around mice, as was reported for *Pituophis melanoleucus*, whereas four individuals of *Python molurus* and three individuals of *Boa constrictor* used mainly ventral bends. In all three lineages the epaxial muscles fire during coil formation and intermittently during sustained constriction; the bursts of muscle activity appear to be associated with high pressures (to over 300 mm Hg) applied to the prey. These results suggest that the ancestral pattern of constriction involved lateral bending and that pythons and boas use a derived posture. The muscle activity patterns indicate that constriction motor patterns are homologous in these diverse snake lineages. **STOYE PHYSIOLOGY & PHYSIOLOGICAL ECOLOGY**

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The scaling of constriction strength in snakes

Constriction is a key behavioral innovation and a homologous character for the majority of snakes. During constriction, prey is immobilized using pressure exerted by two or more points on a snake's body. Although constriction behavior is a sustained motor pattern lasting anywhere from seconds to several minutes, recent studies have shown that pressure is exerted intermittently in response to prey movement. Studies of snakes during feeding also suggest that constriction pressure may vary between taxa. We tested how constriction pressure relates to cross-sectional area within and among species of constrictors. Because force exertion is directly proportional to muscle cross-sectional area, we predicted that (1) constriction pressure in snakes would scale with body diameter and with the number of loops applied to the prey, and (2) slender snakes would apply more loops than thicker snakes to prey of the same relative size. By observing constriction and recording the pressures exerted on the prey by multiple individuals of *Loxocemus bicolor*, *Boa constrictor*, and *Python molurus*, we found that smaller individuals generally used more loops but still exerted lower pressures on the prey than large individuals. These results suggest that behavior (number of loops) can only partially compensate for a mechanical constraint (size-dependent strength) during constriction in snakes.

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A revised age and growth model for blacknose shark from the eastern Gulf of Mexico using x-ray radiography

Underestimates of age can seriously bias any resulting demographic or stock assessment models. In a previous study on blacknose shark, *Carcharhinus*

acronotus, in the eastern Gulf of Mexico, elucidation of bands using thin sections of vertebrae resulting in poor readability and the most successful technique was to count bands on vertebrae half sections. The utilization of half sections can be problematic because of the difficulty in discerning bands on the edge. Consequently, the oldest aged shark from that study was 4.5+ years although tag-recapture data indicated that sharks could be much older. To develop more accurate age estimates, we reexamined the original samples using x-ray radiography and developed a revised age and growth model for blacknose shark in the eastern Gulf of Mexico. Estimates of the von Bertalanffy growth model using revised counts are $L_{inf}=1360$ mm fork length, $k=0.10/yr$, and $t_0=-3.22$ yr for females and $L_{inf}=1053$ mm fork length, $k=0.22/yr$, and $t_0=-2.04$ yr for males. These results were significantly different from the previous estimates. Moreover, the oldest aged sharks are 11.5+ and 9.5+ years for females and males, respectively.

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The reproductive ecology of the Western Slimy Salamander (*Plethodon albagula*) from a mine shaft in the Ouachita National Forest, Arkansas

The western slimy salamander (*Plethodon albagula*) is a large woodland salamander which inhabits woody, rocky hillsides in north and western Arkansas and occasionally enters the twilight zones of mine shafts and caves. Spillway Mine, an abandoned mine shaft in the Ouachita National Forest (Garland Co., AR), offers a unique opportunity to study *P. albagula* use of one such mine shaft. The reproductive ecology was examined for the population of *P. albagula* which utilize the mine shaft to brood and defend egg clutches. We measured egg diameter, clutch size, and number of clutches during August-December 1999-2004. Monthly average egg diameter growth, average brooding time, and number of females brooding were compared to determine both annual and long-term changes in the reproductive output of the females utilizing the mine shaft. *Plethodon albagula* were also found utilizing the mine for summer and winter refuge. Spillway Mine provided refuge for over 256 *P. albagula* (114 females; eight males; 134 juveniles) during June-August 2004. A number of females identified during the summer of 2004 defended nest sites prior to oviposition and brooded clutches during fall 2004 at the specific site where they were identified during the previous summer. This observation suggests that *P. albagula* secure specific nest sites.

***MILLER, BRIAN T.; NIEMILLER, MATTHEW L.**

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A survey for stream-dwelling hemidactyline salamanders in caves of middle and eastern Tennessee

Forty-four subterranean streams were surveyed for hemidactyline salamanders from June 2004 through March 2005. Subterranean streams surveyed were located in the Inner Central Basin, outer Central Basin, Eastern Highland Rim,

Cumberland Plateau Escarpment, and Ridge and Valley Physiographic Provinces. A total of 543 hemidactyline salamanders of seven species were identified during the survey; rarely were more than three species found inhabiting the same cave-stream. The cave salamander, *Eurycea lucifuga*, which was found inhabiting subterranean streams in each of the physiographic provinces, had the largest distribution and was found in more caves (28) than any of the other species; however, fewer than 10 individuals were found during any stream survey. The Tennessee cave salamander, *Gyrinophilus palleucus*, was found in 12 subterranean streams, including two in the Central Basin, seven on the Cumberland Plateau Escarpment, and three on the Eastern Highland Rim. In contrast to *E. lucifuga*, *G. palleucus* populations were often large; *G. palleucus* was the most abundant salamander in 10 of the 12 caves in which it was found. The Berry Cave salamander, *G. gulolineatus*, was found in four caves, all in the Ridge and Valley Physiographic Province. The spring salamander, *G. porphyriticus*, was found in five caves, four on the Eastern Highland Rim and one in the Ridge and Valley Physiographic Province. The red salamander, *Pseudotriton ruber*, was found in nine caves scattered throughout the Eastern Highland Rim, Outer Nashville Basin, and Plateau Escarpment. The southern two-lined salamander, *E. cirrigera*, was found inhabiting four caves on the Eastern Highland Rim and neighboring Plateau Escarpment. The long-tailed salamander, *E. longicauda*, was found in two caves, one in the Outer Nashville Basin and one on the Eastern Highland Rim. Use of subterranean streams for reproduction, as determined by egg masses, larvae, or gravid females, was documented for all seven species.

***MILLS, MARK S.; SAMPLE, TEFFANY N.; GODFREY, JENNIFER L.; MOSQUERA, SANDRA; CARTER, MARIAH L.**

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Reproductive ecology of an urban population of small-mouthed salamanders (*Ambystoma texanum*): A four-year study

This is the fourth year of our study of the reproductive ecology of the small-mouthed salamander, *Ambystoma texanum*. We completely enclosed a small (250 m²), ephemeral, man-made pond on the campus of Missouri Valley College with a drift fence and pit-fall traps in early February of 2002 and continued to monitor the fence daily throughout the breeding seasons. A total of 649 (369 males, 280 females) adult salamanders entered the pond over the first three seasons. We collected the first salamanders on 20 February 2002, 12 March 2003, and 28 February 2004, which was prior to the pond filling with water on 20 April 2002 and 17 April 2003; however, the pond filled prior to the 2004 breeding season on 10 December 2003. Most (39%) of the breeding adults arrived at the pond from the north and west, although substantial year-to-year variability in entry direction was observed. Sex ratio was highly male-biased in 2002 and 2003 (1.8:1; 3.0:1), with male numbers remaining nearly identical (N = 86 & 88) and females decreasing between the two years (N = 47 & 29); in contrast, the sex ratio in 2004 was 1:1 (194 males, 205 females). In 2002 we documented only 5 juveniles leaving the pond before the pond dried on 3 July. In 2003 no juveniles emerged before the pond dried on 27 June. We captured 452 juveniles emerging from the pond in

2004 before it dried on 30 June. The spring and summer of both 2002 and 2003 were extremely dry; the pond filled late (well after the normal breeding season) and dried early. However, for the 2004 breeding season the pond filled on 10 December 2003 and held water until 30 June; for the 2005 breeding season the pond filled 1 July 2004.

MITCHELL, KERRI E.

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The use of freshwater turtles as indicator species for the bioaccumulation of mercury

Mercury is a nonessential trace element that is liberated from the earth's crust by natural processes as well as compounded in the environment by anthropogenic industrial practices. Organic mercury (CH₃Hg) may cause neurological and reproductive dysfunction in biological organisms and its ability to bioaccumulate in an ecosystem has prompted concern for human health and the welfare of large, primarily carnivorous vertebrates. This study tested mercury concentrations in the aqueous component of the lower Trinity River and identified the abiotic and biotic parameters that influence the ability of this particular ecosystem for mercury assimilation and methylation. Total mercury in the water followed the expected seasonal variations based on the environmental parameters measured, with temperature and dissolved oxygen content (DO) of the water establishing the rate of mercury incorporation and methylation by sulfate-reducing bacteria (SRB) and the availability of bacterial microhabitat. Three turtle species, whose dietary preferences range from primarily herbivorous to almost exclusively carnivorous, were trapped at the Trinity River National Wildlife Refuge and tested for mercury concentrations. The results confirmed the hypothesis that mercury bioaccumulation is a function of trophic level among species and statistical analysis showed that mercury concentrations vary with size only within species. This research revealed that large, carnivorous aquatic turtles may be used as indicator species for harmful levels of environmental toxicants.

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Extinction and reintroduction of sunfish reveal smooth transitions between ecosystem states

Centrarchidae (sunfishes) dominate the fish biomass of many small lakes and the bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) are often viewed as potential keystone species within these systems. A natural event (winterkill) eliminated all bluegill and largemouth bass from Wintergreen Lake, MI in 1977-1978. By reintroducing bass in 1986 and bluegill in 1996, we were able to examine the impact of these two potential keystone species on the lake ecosystem. The reintroduction of bass caused a dramatic decline in the density of

planktivorous fish, with marked effects on zooplankton community structure and water clarity. When we introduced 70 adult bluegill in 1996, the population grew rapidly to over 100,000 bluegill by 2002. The reintroduction of bluegill caused planktivore densities to return to high levels. Recent ecological theory suggest that such changes in planktivore abundance may have dramatic, discontinuous effects on plankton community structure, resulting in abrupt transitions between alternative ecosystem states. However, while changes in planktivore densities in Wintergreen Lake did result in marked shifts in zooplankton community composition, zooplankton size structure, and water clarity, these shifts were very smooth and predictable. Thus, there is little evidence of a hysteretic pattern or alternative stable states in this system where the bluegill and bass act as keystone species.

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Phylogeny of the ray-finned fish (Actinopterygii): Analysis of 336 whole mitochondrial genome sequences

The ray-finned fish, Actinopterygii, form by far the most diversified group of all vertebrates, comprising about 27,580 species placed in 42 orders, 431 families, and 4075 genera. Because of their extraordinary diversity, no one has ever successfully obtain a big picture of actinopterygian phylogeny based on a single data set. Our research group has assembled whole mitochondrial genome sequences from 336 fish species that encompasses whole spectrum of the actinopterygian diversity. Particular attention has been paid to intrarelationships a crown group of actinopterygians, herein called Percomorpha, from which >200 species were sampled. Unambiguously aligned nucleotide sequences of 13,529 bp were subjected to partitioned Bayesian analyses using two clusters of the parallel computing system, each equipped with four Linux nodes. The resultant trees were well resolved and local phylogenies agreed well with those from previous mitogenomic analyses. We identified well supported, but previously unrecognized eight major clades within the Percomorpha; however, their interrelationships were still ambiguous, due apparently to rapid radiation during a short period of time.

MOEN, DANIEL S.

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Cope's rule in cryptodiran turtles: Do extant species reflect a trend of phyletic size increase?

Cope's rule of phyletic size increase is questioned as a general pattern of body size evolution. Most studies of Cope's rule have examined body size trends in the paleontological record; however, neontological approaches are now possible due to the development of model-based comparative methods as well as an abundance of phylogenetic data. A recent study of body size evolution in extant North American freshwater fishes demonstrated that families either display no

significant pattern or show phyletic size decrease; however, no other studies have used model-based comparative methods to examine trends in body size evolution in other extant organisms. Cryptodiran turtles are an excellent group in which to study patterns of body size evolution, as the group's relatively small size has led to the availability of densely-sampled phylogenies for most major clades, and many species show sexual dimorphism in size, which may indicate that the evolution of increased size is important in this group. Using a generalized least-squares approach, I examined whether the phylogenetic distribution of body sizes in extant cryptodiran turtles is consistent with Cope's rule of phyletic size increase. I tested whether the rule accurately describes body size evolution in each of six major clades of cryptodiran turtles and also whether the pattern occurs across the whole tree of cryptodirans ($n = 203$ taxa). The results of these analyses will be discussed in light of previous studies of Cope's rule, with notes on the methodology employed to study trends in the evolution of extant taxa. **SSAR SEIBERT EVOLUTION/SYSTEMATICS**

MOLINES, KARYN

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Use of digital photography for identifying individual marbled salamanders (*Ambystoma opacum*) and its use in population studies

Common mark-recapture techniques can be difficult to use on amphibians because of their sensitive skin and ability to regenerate toes. Concerns regarding potential adverse effects of toe-clipping and other marking techniques have encouraged the development of non-invasive photographic identification techniques. The feasibility of a relatively low cost technique for pattern recognition was evaluated. Between 2001-2003, *Ambystoma opacum* were captured via drift-fence/pitfall traps at three wetlands. A sample of 389 digital images (from a total of 2,378) was selected to examine the utility of identifying individuals by their body patterns and to determine recapture rates. Photos were classified by quantifying crossbars on the head/neck, body, or vent/tail. The pattern of crossbars and spots on the body was coded. Cohorts were sorted by crossbar count, and the body patterns compared. These steps identified the majority of the recaptures. An additional step expanded the cohort size by combining each crossbar cohort with those that had one more or one less crossbar. Adding this step increased my ability to identify 41 of the 43 recaptures. This technique was used to make population estimates and to document aspects of the salamanders' fall breeding migration. Pattern recognition using digital photography required a considerable time investment that may pose limitations in large populations, but could be adapted to smaller populations of species that possess distinctive markings.

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A review of age and growth, reproductive biology, and demography of the white shark, *Carcharodon carcharias*

The von Bertalanffy growth function (VBGF) is given by $L(t) = L_{\infty} - (L_{\infty} - L_0)e^{-kt}$

$\exp(-kt)$, where L_0 is mean size at birth, L_{∞} is mean maximum size, and k is a rate constant with units of reciprocal time that is best interpreted in terms of longevity or number of half-lives ($\ln 2/k$). The time (t) it takes to reach the fraction x of L_{∞} is given by $t = 1/k \ln[(L_{\infty}-L_0)/L_{\infty}(1-x)]$. If we choose $x = 0.95$ and $L_0 = 0.2L_{\infty}$, then longevity is given by $2.77/k = 4.0 \ln 2/k$. The value of $L(t)$ has reached 95% of L_{∞} in four half-lives. Growth functions for three populations of white shark from California, South Africa, and Australia will be reviewed and compared. A pregnant white shark was caught on 13 October 1997 in a set-net off Baisolane, Taiwan with 8 embryos of TL between 0.5 and 0.6 m. Time of capture and length of embryos fit an existing but tentative growth curve that predicts a gestation time of around 15-18 months. Uterine width data of pregnant white shark suggest that female maturity is around 5 m TL and 15 yr. Matrix population models of white shark will be reviewed and an integrodifference equation model explored.

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Natural history of the Indigo Snake: *Drymarchon corais* (Serpentes: Colubridae)

There is a paucity of information available on the Neotropical snake *Drymarchon corais*, with limited information on distribution, fossil record and taxonomy. Most studies have focused on the endangered eastern subspecies, *D. corais couperi*. *Drymarchon corais* includes eight subspecies, and is distributed intermittently from southeastern United States to northern Argentina. The indigo snake is among the largest of the non-venomous colubrids and has an unusually broad diet that includes mammals, birds, amphibians, fishes, and reptiles, even venomous snakes. The large north/south range of *D. corais* may result in morphological and ecological variation along the latitudinal gradient. Here we describe the morphology and feeding ecology of the Indigo snake (*Drymarchon corais*). We collected data from 240 museum specimens representing localities in South, Central and North America, to examine variation within the species across its range. Snout-vent length ranged from 274 to 2181 mm (357-1820 mm in males; 470-1872 mm in females). We found 66 prey items in 54 animals. Diet consisted of snakes (31.8%), lizards (15.2%), birds (12.1%), amphibians (12.1%), mammals (9.1%), fishes (3.0%), and centipedes (1.5%). There was no significant difference in size or feeding ecology between juveniles and adults or males and females. Based on preliminary results, we found no significant trend in size or feeding ecology across the latitudinal range.

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Is there an optimal length for the rattlesnake rattle?

Rattling by rattlesnakes is energetically expensive. Therefore, features that reduce the cost of rattling are important to shaker muscle and rattlesnake

physiology, and probably to rattlesnake behavior and ecology. The cost of rattling is affected by the pattern of rattle motion, which in turn is affected by rattle length. We studied how rattle length affects rattle movement and mechanical energy output in western diamond-backed rattlesnakes (*Crotalus atrox*). Specifically, we removed rattle segments one at a time and video taped rattling at each rattle length. From the videos, we measured rattle oscillation frequency, displacement, and kinetic energy. Thus far, we have found that longer rattles have lower kinetic energy and hence a lower cost of rattling than short rattles, mainly because longer rattles undergo smaller displacements and develop standing wave oscillations containing one or more nodes. The positions of the nodes vary slightly with rattling frequency and other factors. As rattle length increases beyond that which produces a node, rattle segments distal to the node undergo very large displacements, which induce large torques that may cause the segments to break off. We are currently analyzing whether these rattle lengths represent high-energy states that are difficult to exceed without breakage, even though greater lengths may eventually achieve lower energy states. These results point to important questions about evolutionary loss of the rattle and rattling behavior, such as whether intermediate states of rattle reduction actually have higher energy costs than typical or vestigial rattles.

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Effects of human disturbance on the nesting and basking habits of yellow-blotched map turtles (*Graptemys flavimaculata*)

Considerable recent attention has focused on how human disturbance alters the behavior of imperiled taxa, and data on such impacts are common for waterfowl, marine mammals, and some large game animals. However, little is known about how human disturbances affect reptiles, perhaps because most reptiles are secretive and are not commonly seen by the public. We studied the impact of human disturbances on the nesting and basking behavior of the Yellow-blotched Map Turtle (*Graptemys flavimaculata*) on the Pascagoula River in southeastern Mississippi, USA. We found that both nesting and basking behavior of map turtles were altered by human recreational activities. Turtles attempting to nest commonly abandoned their attempts upon the approach of a boat, and prior to nesting, numerous individuals waited several hours near the beach without emerging to nest. Basking turtles frequently dove into the water upon the approach of a boat and some did not return to basking. Anglers in small boats that remained in the vicinity of basking sites caused the most disturbances, whereas jet-skies caused fewer disturbances. Although we cannot determine the exact population consequences of such disturbances, our data suggest that interruption of nesting activities may have an especially severe impact on the viability of this population.

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The impact of a long-term snake introduction on a threatened toad in Mallorca, Spain

Much of our knowledge on the impact of introduced species on native ecosystems comes from case studies documenting relatively recent introductions, typically within a time frame of years or decades. Introductions dating back further may provide an insight into longer-term effects of introduced species on native fauna. When the Romans arrived on the island of Mallorca, Spain, approximately 2000 years ago, they brought with them a variety of non-native species. Archeological and, more recently, molecular evidence supports the idea that the viperine snake, *Natrix maura*, appeared on Mallorca at this time. Much of the native fauna was subsequently driven to extinction including, it was believed, all native amphibians. In 1980, however, living individuals of the Mallorcan midwife toad, *Alytes muletensis*, were discovered in a remote limestone gorge in the northwest of the island; subsequent surveys have revealed a total of 19 toad breeding sites. The snake continues to impact toad populations and tadpoles exhibit species-specific behavioral and morphological antipredator responses toward snakes. Being an island species with no natural vertebrate predators, it is likely that the toad has evolved these responses since the introduction of *N. maura* to Mallorca. The eradication of the snake from Mallorca is likely an unrealistic goal; however the effectiveness of removing snakes on sight from toad breeding areas is unknown. Abundant snake populations appear to be maintained by the presence of introduced green frogs, further compounding the issue. The recovery program for the toad has combined a captive-breeding and reintroduction program (currently suspended in light of amphibian disease issues) with the construction of artificial cisterns; a strategy that has proven to be extremely effective in expanding the range of the toad despite continued predation pressure from snakes. The recovery of the toad may have been aided by the evolution of behavioral and morphological defenses.

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Using swimming performance as a predictor of dispersal in the invasive round goby

The round goby, *Neogobius melanostomus*, is an invasive species to the Great Lakes region. It successfully outcompetes native fishes and poses a human health concern, yet research has not addressed the dispersal patterns and mechanisms of the round goby as a potential tool for management. In order to understand swimming as a mechanism of dispersal and predict patterns of distribution, the objective of this project is to identify the ontogenetic stage at which the round goby achieves optimal swimming performance. The hypothesis is that round gobies exhibit allometric growth in pectoral fin morphological characteristics and swimming performance, demonstrating an optimal ability to disperse as adults. Juvenile and adult round gobies collected from Lake Michigan were brought into

the lab to perform a Ucrit swimming test in a flow tank. The pectoral fin of the gobies was dissected, photographed, and measured for morphometric analysis to quantify functionally relevant parameters, including aspect ratio, fin length and area. Fin measurements relative to body size and swimming performance were compared between size classes to test for allometric differences in ontogenetic stages. The conclusions will be discussed. **STORER ICHTHYOLOGY**

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Call transmission of *Rana clamitans* and *Pseudacris crucifer* in two different environments

Animals that communicate by sound emit signals in ways that will be detected and recognized by a recipient. Sound transmission characteristics differ between air and aquatic environments, and so animals could optimize communication according to their calling habitat. Calls of two species were analyzed for transmission efficiency and auditory characteristics in air and water. *Rana clamitans* males often call in water and *Pseudacris crucifer* males will call on the surface. We analyzed some call parameters that are important for recognition in both species such as frequency, number of pulses and call duration and compare these parameters in the different transmission media.

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Rediscovery of *Stygichthys typhlops* Brittan & Böhlke, a subterranean characiform fish from Jaíba, Eastern Brazil

South American freshwaters are home to a number of ichthyological enigmas. One of the most intriguing is the subterranean fish *Stygichthys typhlops*. For over 40 years, the species, sole member of its genus, has remained known from a single juvenile specimen accidentally collected during a well-drilling operation at Jaíba, Brazil. Some peculiar morphological features of that specimen indicated that the fish was of special systematic interest. However, detailed studies were impossible due to lack of study material. A recent expedition by the authors was successful in locating and securing additional specimens in two hand-dug wells located near the type-locality. The additional material permitted, for the first time, a study of the adult form of *S. typhlops*, as well as of its anatomy and possible relationships. Our new data corroborate that *Stygichthys* is a characiform, but previous allocation in Characidae, as well as in any of the subgroups therein, are shown to be erroneous. In fact, there is no evidence supporting a close relationship of *Stygichthys* with any single characiform family.

Rather, the genus seems to be the sister group to a multifamilial clade of characiforms. Our field and aquarium observations of live specimens also yielded original information on the behavior and habitat of *Stygichthys typhlops*. The fish is a solitary, calm swimmer, with low levels of spontaneous activity. According to local information, *S. typhlops* was common until 5-10 years ago in wells and springs in the region. Its distribution area estimated on the basis on confirmed localities is at least 25 km². Recent and massive irrigation projects at the type-locality have led to a marked decrease in water table levels. This may result in significant habitat loss, posing a major concern about the survival of *S. typhlops*. Our presentation includes color photographs and film footage of live specimens of *S. typhlops*.

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Geographic variation in effects of toad-feeding on chemical preference and antipredator responses in *Rhabdophis tigrinus*

An Asian natricine snake, *Rhabdophis tigrinus*, which typically forages on toads, has unusual nuchal glands on its dorsal neck region containing secretions chemically comparable to cardiac steroids found in toads. Concurrent research reported at this meeting indicates that the chemical compounds of the glands are, at least partially, sequestered from toads ingested by snakes. Furthermore, the snake exhibits several peculiar antipredator displays, such as neck arch and neck butting, which presumably depend on the deterrent effects of the gland secretions. Previously we have demonstrated that hatchlings from a toad-free island perform less neck arch and neck butting, and more fleeing, than hatchlings from areas sympatric with toads. Here we compare the chemical prey preferences of ingestively naive hatchlings from populations both sympatric and allopatric with toads. Hatchlings showed higher tongue flick scores to chemicals of toads and two species of frogs than control chemicals, irrespective of the populations. We also investigated possible influence of diet on the subsequent antipredator responses of juveniles. Hatchlings from toad-free and toad-rich islands were divided into three groups and reared with diets of toads & fish, frog & fish, or only fish. Antipredator responses were tested when the snakes were about three and six months old. At three months the snakes from the toad-rich island exhibited neck arch significantly more frequently in toad & fish group than in the other two groups, whereas those from the toad-free island showed only a trend for higher mean rates of performing neck arch in the toad & fish group than in the others. At the age of six months, however, no significant effects of diets on antipredator responses were detected in either island. These population differences and similarities will be discussed from the viewpoint of evolutionary history and ontogeny.

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A new seawater facility for experimental research on large elasmobranchs and other marine species

Mote Marine Laboratory's Center for Shark Research recently completed construction of a new research facility dedicated to the experimental study of large elasmobranchs and other marine species. This facility is designed to serve the needs of residential and visiting researchers, including collaborating scientists and students. The facility includes two large, oval-shaped tanks, one 9 m x 17 m x 2 m with 280,000 L capacity and the other 6 m x 12 m x 2 m with 152,000 L capacity. Both tanks are equipped with observation windows, access platform, independent filtration and heater/chiller units and an overhead web-accessible video system for experimental observation is planned. Four smaller round tanks (2 m and 2.5 m) with independent life support systems provide space for smaller elasmobranchs. Capital improvements to seawater supply and treatment systems guarantee availability of high quality seawater, especially during periodic red tide events. These improvements include two 15hp seawater pumps, new pipelines, improved storage tank volume and filtration/sterilization systems providing 1,520,000 L of raw seawater daily for open loop operations and 380,000 L of sterilized seawater storage for closed loop operations. The facility has been designed and constructed to support many types of elasmobranch research including physiological, behavioral and environmental studies and technology development. Since the facility's completion, large specimens of four shark species (*Sphyrna mokarran*, *Carcharhinus limbatus*, *C. leucas* and *C. plumbeus*) have been successfully maintained in captivity. Currently, graduate students are conducting research on feeding mechanisms and morphology of the great hammerhead shark using the facility, and studies on elasmobranch electroreception, orientation and navigation are planned. Applications to use this new research facility are encouraged from scientific colleagues, graduate students, undergraduate student interns, and educators. Please contact Robert Hueter (rhueter@mote.org or 941-388-4441) at the Center for Shark Research, Mote Marine Laboratory to submit a research proposal.

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Conservation implications of polybrominated diphenyl ethers in two species of turtle from the Tennessee River

Polybrominated diphenyl ethers (PBDEs: flame-retardants) are chemicals added to plastics, textiles, and electronic circuitry for fire protection and have become environmental contaminants of increasing concern. These lipophilic compounds bioaccumulate in animal tissues, and have been found to be persistent in the environment. PBDEs have been found in human adipose tissue, blood and breast

milk. They have also been found in fish-eating birds and mammals. Studies indicate that PBDE 47, a commonly measured congener, has the potential to induce cancer by way of a mechanism similar to other persistent organic pollutants such as DDT and PCBs. In this study, we quantified the presence and assessed the ecological implications of PBDEs in a Tennessee riverine turtle assemblage. From June through September 2004, plasma samples were collected from two riverine turtle species, the Cumberland slider (*Trachemys scripta*) and the stinkpot turtle (*Sternotherus odoratus*). Five male and five females from each turtle species were analyzed using gas chromatography mass spectrometry in electron impact mode for the presence of 23 PBDE congeners. PBDE 47, 153, and 154 were the only congeners present in all *S. odoratus* samples. In *T. scripta*, PBDE 47, 153, and 154 were present in all five male samples. All five female samples contained PBDE 47, but only four samples contained PBDE 153 and 154. Average total predominant PBDE concentrations (sum of PBDE 47, 99, 100, 153, 154) for *T. scripta* were 0.875 ng/g for males and 0.506 ng/g for females. Average total predominant PBDE concentrations for *S. odoratus* males were 1.37 ng/g and 0.963 ng/g for females. The ecological parameters and potential consequence to riverine turtles posed by the PBDEs detected in our study will be discussed.

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Levels of persistent organic pollutants (POPs) in plasma from two species of riverine turtle

POPs are characterized by persistence in the environment, biomagnification through the food web, global transport, and adverse effects on human health and the environment. We report the concentrations of two classes of POPs in plasma from two species of turtle, the Cumberland slider (*Trachemys scripta*), and the stinkpot turtle (*Sternotherus odoratus*) captured in the Tennessee River Gorge, between June and September 2004. Five males and five female samples from each species were analyzed for 101 compounds (83 PCB congeners, 6 DDT congeners, and 12 additional organochlorine pesticides) using gas chromatography mass spectrometry in electron impact mode. The average total PCB (sum of individual congeners) concentrations in *S. odoratus* were 12.7 ng/g, and 13.0 ng/g, for males and females, respectively. Average total DDT concentrations for *S. odoratus* males and females were 1.5 ng/g and 6.7 ng/g, respectively. Average total PCB concentrations for *T. scripta*, were 15.4 ng/g for males and 7.2 ng/g for females. Average total DDT for *T. scripta* males was 0.545 ng/g and 0.597 ng/g for females, with 4,4'-DDE as the main metabolite. In general, similar studies involving the loggerhead sea turtle (*Caretta caretta*) yielded total PCB values that were approximately half our reported values for both species studied. Average total PCB concentrations in *S. odoratus* were generally one to three orders of magnitude lower than those reported in the literature for some marine mammals. Total PCB concentrations in both turtle species studied were approximately one order magnitude lower than previously published concentrations for snapping turtles (*Chelydra serpentina*) in Hamilton Harbor and Lynde Creek, Lake Ontario.

Generally, concentrations of 4,4'-DDE in *T. scripta* were lower than those previously published for the American alligator (*Alligator mississippiensis*) and *C. serpentina*. In addition, data from other vertebrate species will be discussed for general ecological comparisons.

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Molecular systematics of South American amphisbaenians (Reptilia, Squamata)

Amphisbaenidae is the most speciose family of amphisbaenians; 17 genera and ca.140 species inhabit Africa and South America primarily. Due to their secretive life style, they are poorly represented in museums, and the lack of tissue samples for molecular analyses has been a real limitation for understanding their phylogenetic relationships using genetic data. Phylogenetic relationships based only on morphology (Kearney 2003) have been considered problematic because the majority of characters are functionally correlated, compromising the independence of the characters for such analyses. The present study reports a detailed examination of the relationships of the six Brazilian genera of amphisbaenids using genetic data. In total, 25 species in six genera and four outgroups were sequenced. Nuclear and mitochondrial data were obtained; genes included were RAG-1, C-MOS, 16S, and ND2 respectively. Phylogenetic relationships were inferred using Maximum Parsimony and Bayesian analyses (unpartitioned and partitioned analyses). My results suggest that South American amphisbaenids represent a monophyletic lineage; within this lineage, three of the six genera are not monophyletic. The three morphological characters (cranial shape, number of body annuli, and number of preloacal pores) by which Brazilian amphisbaenians have been diagnosed are homoplastic and additional morphological characters are needed to recognize such taxonomic diversity. Therefore, new molecular and morphological characters are being examined in order to better assess amphisbaenid relationships.

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Suction performance and feeding biology of the nurse shark *Ginglymostoma cirratum*

To investigate the relationship between suction performance, morphology and prey capture in the obligate suction feeding nurse shark *Ginglymostoma cirratum*, pressure recordings were taken both internally and externally on laboratory and field-tested sharks. Food capture, which is invariably by suction, is relatively stereotyped, rapid, and explosive, generating the lowest sub-ambient suction

pressures (-110 kPa) recorded for any aquatic vertebrate. Similar to other suction feeding fishes, the duration of buccal expansion, which occurs in approximately 32-56 msec, is inversely proportional to sub-ambient suction pressure measured at the oral aperture. The suction pressure is on average -7 kPa greater at the mouth than within the buccopharyngeal cavity as expected due to the restricted oral aperture. Buccopharyngeal pressure starts to decline 33 msec before the mandible starts to depress, and peak internal sub-ambient pressure coincides with peak mandibular depression. The rate of buccal and pharyngeal expansion appears to be the primary determinant of the magnitude of sub-ambient suction pressure. Upper jaw protrusion, which reaches peak anteroventral excursion during the compressive phase of the bite and is predominantly confined within the buccal cavity, has no apparent function during prey capture, other than to grasp large prey. Due to the rapidly diminishing influence of suction in front of the mouth, the nurse shark must closely approach its prey to entrain it within the water being sucked into the mouth. We hypothesize that the specialized morphology and suction performance of the nurse shark permits prey capture by stalking, ambushing, and hunting by expectation within reef crevices, particularly at night when it can closely approach unsuspecting prey.

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Diet of eastern box turtles (*Terrapene carolina carolina*) inhabiting upland and tidal wetland habitats

Box turtles are omnivores that take a variety of plant and animal matter. In 2004, we investigated the diet and habitat use of turtles that moved between a riparian forest and adjacent tidal wetlands along the Patuxent River (Coastal Plain) in Anne Arundel County, Maryland. We identified specific diet items by observing foraging turtles and by examining feces. We also analyzed diet by measuring the stable isotopes of carbon and nitrogen in turtle tissue and in potential food items. Thirty-nine turtles were observed consuming 15 different types of food. Examination of fecal samples from 22 turtles revealed the remains of arthropods (40% of samples), plant matter (23%) and mushrooms (16%). Mass spectrometry was used to determine the ratio of heavy to light C and N isotopes in toenails from 46 turtles and in a large sample of food items collected in all habitats used by the turtles. While most turtles had a diet based largely on the upland ecosystem, eight turtles (17% of total) had enriched ^{15}N values of +8‰ or greater indicating diets composed largely of wetland food sources. Although upland ecosystems probably provide the major food source for most turtles, our study reveals that wetlands play a more important role in box turtle nutrition than has been previously appreciated.

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Attacking the invaders: How a generalist snake forages successfully for three introduced prey species.

Exotic species are presumed to exact negative effects in the habitats where they have been introduced. These species, however, can provide new sources of prey for predator species native to those habitats. Predatory generalists have greater potential than specialists to capitalize on introduced prey species because a generalist might already exhibit a foraging behavior that facilitates successful capture of the prey. We examined the foraging and prey handling behaviors of *Thamnophis hammondi* offered three different prey types (*Lepomis* spp., larval *Rana catesbeiana*, and juvenile *Xenopus laevis*), all introduced into the range of *T. hammondi*. Durations of foraging and prey handling behaviors were analyzed to determine if these behaviors varied by snake gender, collection locality, or prey type. Differences in behavior type and duration as a function of gender or locality were absent. Subject behaviors varied between prey types, with differences in the duration of the following behaviors: time overland, cruising, margin wandering, midwater diving, prey-orienting underwater, and ingesting. Subjects successfully captured all prey types, with the highest attack and success rates when foraging for *R. catesbeiana* larvae. Our results indicate that *T. hammondi* exhibits a variable repertoire of foraging behaviors. The generalist nature of this predator allows it to successfully depredate prey types that have become available in its habitat relatively recently.

***MULLIN, ZACH; MUNSCHER, ERIC; BUTLER, JOSEPH**

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Affects of raccoon (*Procyon lotor*) removal on survivorship of diamondback terrapin (*Malaclemys terrapin*) nests in northeastern Florida

Raccoons (*Procyon lotor*) are known to be major predators of turtle nests anywhere they cohabitate. In 1997 and 2000, a diamondback terrapin (*Malaclemys terrapin*) nesting beach on an island in northeastern Florida was monitored from 1 May through 31 October. Nests were identified, marked, and monitored for disturbance by predators. Predators were found to be raccoons, crows, boat-tailed grackles, armadillos, ghost crabs and two species of plant roots. The major predator is by far the raccoon. In 1997, 81.9% of all nests were destroyed by predators and 86.5% in 2000. We feel that this level of predation cannot be sustained long-term by the terrapin population. This study involves removing as many raccoons as possible starting 15 February 2005 and monitoring terrapin nesting from 1 May through 31 October. We estimate there are as many as 50 raccoons inhabiting the island. We are trapping them using live traps, sedating and humanely euthanizing them. The raccoon tissues and organs are to be used in a variety of separate analyses. During daily surveys, newly oviposited terrapin nests will be located and marked, and previously marked nests will be checked for predation, washout, or hatching. Every effort will be made to identify the type of nest predator to evaluate if predation by animals other than raccoons

increases. By eliminating raccoons as terrapin nest predators, we will be able to quantify their impact on egg survivorship and better understand the roles other nest predators play. With our results, we hope to be able to make recommendations about predator control with regards to terrapin nesting habitat.

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Characteristics of the semi-aquatic turtle assemblage at Wekiwa Springs State Park

Using mark-recapture data, population size, sex ratios, density, and biomass were calculated for four species of semi-aquatic turtles in the 1.2 ha lagoon at Wekiwa Springs State Park, Orange and Seminole counties, Florida. This study began in 2000, with week-long capture sessions in March and May of each year to current 2005. The four most common species captured were the Florida peninsula cooter (*Pseudemys floridana peninsularis*), the Florida redbelly (*P. nelsoni*), the common musk turtle (*Sternotherus odoratus*) and the loggerhead musk turtle (*S. minor minor*). Population estimates were calculated using two closed-system techniques (Schnabel method and Schumacher-Eschmeyer method) and an open-system technique (Jolly-Seber method). Point estimates obtained using the Schnabel method for the 2004 season reveal that ca. 286 *P. floridana peninsularis*, 171 *P. nelsoni*, 178 *S. odoratus* and 439 *S. minor minor* currently inhabit the lagoon area. Density and biomass of these species are high in comparison to estimates obtained from other studies of the same or similar species elsewhere. Sex ratios of all species were not significantly different from 1:1. This monitoring study was undertaken in order to assess the continued impact of development on the area surrounding the park. The flood plain charging this spring includes much of the metropolitan area of Orlando, one of the fastest growing areas in the United States. It has been estimated that in the next 20 years, flow from this spring could be halved. It is therefore imperative to closely monitor this turtle assemblage in order to quickly and accurately report the impacts of reduced flow and thereby allow for rapid and effective management to occur.

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Consumption rates in relation to abundance of gag residing on artificial reefs of contrasting size off the west coast of Florida

Initially in 1997, gag (*Mycteroperca microlepis*; Serranidae) that occurred in lower abundance on smaller (4-cube) artificial reefs had better growth and condition compared to gag from larger (16-cube) reefs where their abundance was high. Since 1997, gag abundance has declined on the 16-cube reefs and differences in growth and condition between reef sizes has either decreased or reversed. In 2000-2004, we estimated differential prey consumption rates of gag as a function of their density to examine this differential growth and condition. During the summer/fall, prey consumption by all gag was predominantly pelagic planktivorous fishes, including scaled sardine, Spanish sardine, round scad and juvenile tomtate. Preliminary analysis indicated that the abundance of these baitfishes was not different between small versus large reefs. Field estimates of average daily food consumption and average daily gross energy consumption of gag ranged between 1.6 and 2.2 % body weight per day and 11 and 24 cal/g body weight per day, respectively. Gag on the smaller 4-cube reefs consumed a greater diversity of prey than gag on the larger 16-cube reefs, whereas the diet of gag on 16-cube reefs contained relatively more portunid crabs than gag on 4-cube reefs. Observed differences in prey consumption and gross energy consumption in relation to gag abundance may explain some, but not all, of the observable differences in gag growth and condition, which vary inter-annually.

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Comparative phylogeography of three central highlands minnows
(Ostariophysi: Cyprinidae)

The cyprinid fishes *Notropis telescopus* and *Cyprinella galactura* share a congruent disjunct distribution in the Ozark and Appalachian highlands, which are separated by the lowland floodplain of the Mississippi River. *Notropis boops* exhibits a similar pattern but is more widely distributed, extending southward into the Ouachita Highlands of central Arkansas and northward to glaciated regions of the Ohio River drainage. Previous studies indicated morphological differences across the Mississippi River for all three species. I investigated molecular divergence within and among these species comparing complete sequences of the mitochondrial cytochrome *b* gene for populations across their ranges. Phylogenetic analyses were performed using both unweighted parsimony and bayesian methods. Sequence divergences were corrected for multiple substitutions and inherited ancestral polymorphisms. Phylogenetic analyses recover distinct eastern and western phylogroups within *N. telescopus*

and *C. galactura*. Corrected sequence divergences for *N. telescopus* and *C. galactura* indicate that populations have been distinct since the early or middle Pleistocene, approx. 1 million YBP. Within *N. boops*, phylogenetic trees show eastern populations nested within western populations. Red River (OK) populations of *N. boops* are deeply divergent from all other populations, which are genetically homogenous across the remainder of the range of this species. These results, together with low sequence divergence argue for a recent (post-Pleistocene) west to east dispersal of *N. boops* across the Mississippi River.

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Validated age estimates for the shortfin mako, *Isurus oxyrinchus*, in the North Atlantic Ocean

Age and growth estimates for *Isurus oxyrinchus* derived from vertebral centra of 258 specimens (118 males, 140 females), ranging in size from 64 to 340 cm fork length (FL) were compared with data from 22 tag-recaptured individuals (74-193 cm FL) and length-frequency data from 1,822 individuals (1,035 males, 787 females; 65-215 cm FL). Annual band pair deposition, confirmed by a concurrent bomb radiocarbon validation study, was used as the basis for band interpretation. Validation was further confirmed with a tetracycline-injected male shortfin mako recaptured after being at liberty off South Africa for one year and aged at 18 years. Growth rates from tag-recapture analysis were higher than those derived from vertebral annuli and were only available from sharks up to 193 cm FL. Modal length-frequency data were used to verify the first four age classes. Growth curves were fitted using both von Bertalanffy and Gompertz methods. The 3-parameter version of the von Bertalanffy growth function produced more reasonable values for males ($L_{inf} = 253$ cm FL, $K = 0.125$ yr⁻¹ (estimated longevity = 21 yr), and $L_0 = 72$ cm). The 3-parameter version of the Gompertz growth function produced more reasonable estimates for females ($L_{inf} = 366$ cm FL, $K = 0.087$ yr⁻¹ (estimated longevity = 38 yr) and $L_0 = 88$ cm. Males and females were aged to 29 (260 cm FL) and 32 years (335 cm FL), respectively. Both sexes grew similarly to age 11 (207 cm FL, 212 cm FL for males and females, respectively) when growth rates decreased in males and remained constant in females. Age at 50% maturity was estimated at 8 years for males (185 cm FL) and 18 years for females (275 cm FL). The species grows slower, matures later and has a longer life span than previously reported in North Atlantic waters.

***NAVA, IMELDA; TORRES, ELIZABETH; WAYNE, ROBERT K.**

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Molecular systematics of bioluminescent marine fishes of the genus *Porichthys* (Batrachoididae) and *P. notatus* genetic differentiation

The genus *Porichthys* (Batrachoididae) is endemic to the New World; 8 species of *Porichthys* are distributed along the Pacific coast of North and South America, and 6 are distributed in the Atlantic. A synapomorphy for *Porichthys* is the more than 700 dermal photophores (bioluminescent organs) on their ventral surface. Our preliminary mitochondrial DNA sequence data suggests that *Porichthys* is monophyletic and that bioluminescence evolved just once within the Batrachoididae. Fishes of the genus *Porichthys* require an exogenous source of luciferin for the bioluminescence reaction that is obtained by consumption of bioluminescent ostracode crustaceans of the genus *Vargula*. *P. notatus* occurs along the Pacific Coast of North America; its range extends from Baja California to British Columbia. Northern populations of *P. notatus* do not bioluminesce, apparently due to a lack of an available dietary source of *Vargula* luciferin. A population of mixed phenotypes of luminescent and non-luminescent individuals has been documented from the San Francisco Bay area.

Mitochondrial DNA sequences from the cytochrome oxidase I and cytochrome b genes were used to examine gene flow between phenotypes and populations of *P. notatus* from throughout its range. Unique haplotypes were found in the northern most populations, suggesting restricted gene flow between northern and southern populations of *P. notatus*. Haplotypes were shared between phenotypes, suggesting that gene flow is not restricted between luminescent and non-luminescent individuals. Significant F_{st} values were detected between samples from Southern sampling sites, suggesting limited gene flow between multiple populations in the Southern part of the range. **SSAR SEIBERT**

EVOLUTION/SYSTEMATICS

NAYLOR, GAVIN J. P.

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Reconciling phylogenies - Contrasting molecular and morphological phylogenies of sharks

There are significant discrepancies between phylogenetic analyses of modern elasmobranchs founded upon morphological and molecular data. Stratigraphic data (heavily biased toward isolated teeth) are more compatible with the molecular tree, suggesting that the neoselachian fossil record contains a few gaps of relatively short duration. By contrast the morphological trees predict numerous lengthy gaps exist in the fossil record of many modern elasmobranch lineages, and that a major radiation of numerous modern elasmobranch lineages occurred prior to the early Jurassic. I will discuss approaches to character reconciliation between morphological and molecular data sets. This involves identifying use of inappropriate molecular evolutionary models in sequence data and homology mis-specification in morphological data sets.

***NAZDROWICZ, NATHAN H.; BOWMAN, JACOB L.**

University of Delaware, Department of Entomology and Wildlife Ecology, Newark, DE 19716, USA

Population ecology of the eastern box turtle in a fragmented landscape

The effects of habitat alterations and fragmentation on eastern box turtle (*Terrapene carolina carolina*) populations remain undetermined. To investigate the status of eastern box turtle populations in a fragmented landscape, we used mark-recapture and radio telemetry (April 2001 - April 2003), and long term data. We estimated population density, sex ratio, age structure, and survival rate on 4 study areas with differing degrees of isolation and human disturbance in northern New Castle County, Delaware. Two study areas (University of Delaware Woodlot and Webb Farm) were isolated forest fragments within a suburban environment immediately surrounded by agriculture; 1 area (Turkey Run) was a forest fragmented by small fields surrounded by low-density development; and 1 area (White Clay Creek) was an interior forest within a state-protected park. We estimated adult population densities of 0.81-0.93, 2.12-3.69, 2.44-4.56, and 2.76-4.99 turtles/ha at the Woodlot, Webb Farm, Turkey Run, and White Clay Creek, respectively. Sex ratios (male: female) were male biased at the Woodlot (3.00:1.00) and White Clay Creek (2.07:1.00), whereas Webb Farm and Turkey Run had balanced sex ratios. Proportion of juveniles was 0%, 25%, 32%, and 6% at the Woodlot, Webb Farm, Turkey Run, and White Clay Creek, respectively. We estimated an annual survival rate of 0.813 (SE = 0.0693), 0.945 (SE = 0.0382), 0.951 (SE = 0.0338), and 0.977 (SE = 0.0230) for the Woodlot, Webb Farm, Turkey Run, and White Clay Creek, respectively. Mortality on the study sites was primarily due to natural causes. Human induced mortality resulted primarily from mowing. We found no evidence of population change during this study at Webb Farm, Turkey Run, or White Clay Creek, whereas the Woodlot population was declining due to low survival and recruitment.

***NAZDROWICZ, NATHAN H.; BOWMAN, JACOB L.; IGLAY, RAYMOND B.**

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Eastern Box Turtle movements in a fragmented landscape

Thread trailers are used to track and measure the real movements of animals. We employed thread trailing on box turtles (*Terrapene carolina carolina*) to elucidate the impacts of forest fragmentation on box turtle movements. We chose 4 study areas that differed in degree of fragmentation ranging from isolated forest fragments to an interior forest to investigate the effect of sex, season, and study area on daily movement. We radio-located 5 random turtles per week per study area and attached a thread trailer for 24 ± 3 hours to measure daily movements. Sex*season*study area ($P = 0.994$) and season*study area ($P = 0.134$) interactions did not affect turtle movements. However, sex*season ($P = 0.049$) and sex*study area ($P = 0.048$) interacted to affect turtle movements. Box turtle movements

varied among seasons with males moving farther than females in the later seasons. Additionally, box turtles in isolated areas moved less than those in more continuous habitat. Fragmentation that creates isolated habitat patches may negatively influence box turtle movements, which could reduce the ability of box turtles to find the resources necessary for survival and reproduction.

NEAR, THOMAS J.

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Centrarchid fishes as a model system for fossil-calibrated molecular divergence time estimation

Molecular clock methods allow biologists to estimate divergence times, which in turn play an important role in comparative studies of many evolutionary processes. It is well known that molecular age estimates can be biased by heterogeneity in rates of molecular evolution, but less attention has been paid to the issue of potentially erroneous fossil calibrations. In this study we estimate the timing of diversification in Centrarchidae, an endemic major lineage of the diverse North American freshwater fish fauna, through a new approach to fossil calibration and molecular evolutionary model selection. Given a completely resolved multi-gene molecular phylogeny and a set of multiple fossil inferred age estimates, we tested for potentially erroneous fossil calibrations using a recently developed fossil cross-validation method. We also used fossil information to guide the selection of the optimal molecular evolutionary model with a new fossil jack-knife method in a fossil-based model cross-validation. The centrarchid phylogeny resulted from a mixed model Bayesian strategy that included fourteen separate data partitions sampled from three mtDNA and four nuclear genes. Ten of the 31 interspecific nodes in the centrarchid phylogeny were assigned a minimal age estimate from the centrarchid fossil record. Our analyses identified four fossil dates that were inconsistent with the other fossils, and we removed them from the molecular dating analysis. Using fossil-based model cross-validation to determine the optimal smoothing value in penalized likelihood analysis, and six mutually consistent fossil calibrations, the age of the most recent common ancestor of Centrarchidae was 33.59 million years ago (mya). These results place the origin of the centrarchid radiation at a time of major faunal turnover as the fossil record indicates that the most diverse lineages of the North American freshwater fish fauna originated at the Eocene-Oligocene boundary, approximately 34 mya. Our analyses demonstrate the utility of fossil cross-validation to critically assess individual fossil calibration points, providing the ability to discriminate between consistent and inconsistent fossil age estimates that are used for calibrating molecular phylogenies.

NEAR, THOMAS J.

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Molecular phylogenetics of *Percina* (Percidae: Etheostomatinae)

Previous molecular phylogenetic analyses of the darter clade *Percina* using

mtDNA gene sequences have revealed extensive non-monophyly of several subgenera. In an effort to increase node resolution in the mtDNA gene trees, I have gathered complete mtDNA gene sequences from cytochrome b and NADH subunit 2. To provide a test of previous mtDNA gene trees, I collected sequence data from the nuclear encoded S7 ribosomal protein intron 1. These data sets were collected from all species of *Percina*. Phylogenetic analysis of these data sets suggest that many previously recognized subgenera in *Percina* are not monophyletic. These include *Ericosma*, *Hadropterus*, and *Alvordius*. Since darters are more frequently the subject of comparative studies, North American ichthyologists are going to have to decide if they will continue to recognize such non-monophyletic clades, or if we are more willing to provide phylogenetic-based hypotheses of relationships to a broad, and interested, community of ecologists and evolutionary biologists.

***NEELY, DAVID A.; ESPINASA, LUIS; MAYDEN, RICHARD L.**

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Systematics of a troglomorphic sculpin from central Pennsylvania, eastern United States (Teleostei: Cottidae).

Mitochondrial sequence data were used to assess phylogenetic relationships and patterns of genetic variation within a population of a presumptive troglomorphic freshwater sculpin from the Susquehanna Basin of central Pennsylvania, in the eastern United States. This population has only recently been identified and to date is only known from a single cave. Hypogean specimens display morphological characteristics inconsistent with proximal populations of both *Cottus bairdii*) and *Cottus cognatus*, including elongated pectoral fins, enlarged pores of the cephalic lateralis system, increased subdermal lipid deposits, reduction of the tectum opticum, and reduced dermal pigmentation. We generated control region sequences from specimens of the cave population and epigeal populations of both *C. bairdii* and *C. cognatus*. All analyses suggest strong geographic subdivision within each of the epigeal taxa, recent (post-glacial) differentiation of the troglomorphic samples, and some indication of either introgression or ongoing hybridization with epigeal populations. The rapid development of unique morphological traits in the face of considerable gene flow provides a unique opportunity to examine adaptive processes.

NEER, JULIE A.

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Incorporating variability in size at birth into growth models for elasmobranchs: Does it make a difference?

In order for age models to be considered accurate regarding the growth dynamics of a species, multiple models or various formulations of the same model may be required to determine which most accurately describes the growth of that species. Historically, the von Bertalanffy growth model (VBGM) with a t_0 parameter has been the model applied most to elasmobranchs. More recently,

some studies have begun to apply modified versions of the von Bertalanffy growth model. An alternate model introduced by Fabens (1965) reparameterizes the VBGM by removing the α parameter and forcing the model through the Y-intercept (e.g., hypothesized size-at-birth). While this model may be more applicable when there is an inadequate sample of very small individuals, the model still relies on one estimate of size-at-birth when, in reality, size-at-birth varies. To address the issue of variability in size-at-birth, a Monte Carlo simulation was incorporated into the size-at-birth intercept. The details of the methodology will be presented using the bull shark, *Carcharhinus leucas*, as a case study. Results of the analysis will be discussed for the bull shark, as well as several other species such as the finetooth shark, *C. isodon*, blacktip shark, *C. limbatus*, Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, and the bonnethead shark, *Sphyrna tiburo*. This study provides the first attempt to incorporate variability at size-at-birth and provide measures of variability around the individual parameter estimates for elasmobranchs. **AES GRUBER**

NEFF, BRYAN D.

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Sperm competition and alternative mating tactics in bluegill sunfish (*Lepomis macrochirus* R.)

Fishes provide ideal systems to study adaptations to sperm competition. Although it is now well known that males differ in their competitiveness during fertilization, the specific mechanisms that males use during sperm competition to increase their fertilization success are just beginning to be understood. Here, I examine the mechanisms that male bluegill sunfish that utilize alternative mating tactics use during sperm competition. I show that parasitic males called "sneakers" and "satellites" are superior sperm competitors, fertilizing about 80% of the eggs when in direct competition with larger, nest-tending males called "parentals." Although sneakers ejaculate about half a second after parentals and are 1.4 times farther from the female, they release 4 times the number of sperm and appear to have faster swimming sperm, thereby increasing the competitiveness of their ejaculates. Satellites on the other hand release only about half the number of sperm that parentals release, but are 3.7 times closer to the female when spawning. Across the colony, parentals fertilize a majority of the eggs by successfully excluding parasitic males from their nests. These data contribute to our understanding of sperm competition and the evolution of mating systems.

***NEILSON, MATTHEW; STEPIEN, CAROL A.**

Lake Erie Center, Department of Earth, Ecological, and Environmental Sciences, University of Toledo, 6200 Bayshore Rd., Oregon, OH 43618, USA

Molecular phylogeny of the neogobiin fishes (Gobiidae: Neogobiinae)

Systematic identity is an important consideration in understanding the biology of a species, and is of particular importance with invasive species, where taxonomic confusion can influence ecological impact assessments and management efforts. We investigated the systematics of the neogobiin gobies: a

small species flock endemic to the Ponto-Caspian region (Black/Caspian Seas and associated drainages) that are invasive in the North American Great Lakes (since 1990) and central/eastern Europe. The neogobiins include *ca.* 20 species within three genera (*Mesogobius*, *Proterorhinus*, and *Neogobius*) whose taxonomic position and systematic relationships are poorly understood. We analyzed DNA sequence data from the mitochondrial COI and Cytb genes to infer relationships among this subfamily. *Neogobius* appears to be paraphyletic, with marked divergence between the subgenus *Apollonia* (round goby *N. melanostomus* and monkey goby *N. fluviatilis*) and all other neogobiin taxa. *Mesogobius* appears to be the sister genus to *Proterorhinus*, and a clade containing these two genera is sister to all remaining *Neogobius*. Significant divergence is also seen between marine and freshwater types of tubenose goby *Proterorhinus marmoratus*, indicating species level separation between the two forms. The freshwater type of *Proterorhinus* was originally described as *P. semilunaris*, but was later synonymized with *P. marmoratus*. We suggest the resurrection of *P. semilunaris* for the freshwater tubenose goby, and the elevation of *Apollonia* to generic status, rendering four neogobiin genera.

***NELSON, DAVID H.; SCARDAMALIA-NELSON, CYNTHIA.**

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Vertebrate road-kill survey of the Mobile-Bay Causeway

A systematic survey was conducted weekly during 2001-2004 by bicycle (or automobile) on the Mobile Bay Causeway to assess the numbers of vertebrates killed by vehicular traffic. More than 2774 organisms were encountered, representing 120 species of vertebrates: 8 amphibians (n=311), 30 reptiles (n=916), 64 birds (n=1076), and 18 mammals (n=477). Southern leopard frogs and pig frogs accounted for 89% of the amphibian captures. Endangered Alabama red-bellied turtles (*Pseudemys alabamensis*, n=324) were the most common turtle species, accounting for 35% of all reptiles; most of these were hatchlings in March-April or October-November. Six specimens of the green anole (*Anolis carolinensis*) were the only lizards observed. Snakes were dominated by Mississippi green water snakes (n=84), cottonmouths (n=70) and eastern ribbon snakes (n=51). Sixty-three alligators were encountered from March to November (including hatchlings, juveniles and adults). Laughing gulls (n=188) and European starling (n=139) were the most abundant birds. Opossums (n=150) and raccoons (n=140) dominated the mammals (n=478). Hatchlings of Alabama red-bellied turtles, mud turtles and red-eared sliders were encountered in the spring. Our data confirm significant over-wintering in the nest by all of these species. During the past four years, the numbers of road-kill mortalities for hatchling Alabama red-bellied turtles have been 63, 58, 67 and 54 individuals (N=242). In 2004, no hatchlings were encountered in the fall. Flooding associated with Hurricane Ivan may have drowned the embryos or caused them to emerge prematurely.

***NEUWALD, JENNIFER L.; TEMPLETON, ALAN R.**

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Fire management and the effects of gene flow and drift on the Eastern Collared Lizard

Eastern collared lizards, *Crotaphytus collaris collaris*, of the Missouri Ozarks live in glades which are open, rocky habitats imbedded in a forest matrix. Recent fire suppression has degraded glades and made the forest an effective barrier to dispersal, leading to habitat destruction, fragmentation, population isolation and local extinction. Prescribed forest fires have helped to restore the habitat and natural population dynamics of glade species. This study focuses on a reintroduced population of collared lizards that has been subjected to ten years of habitat fragmentation due to fire suppression followed by ten years of habitat restoration due to prescribed burns. Genetic, demographic, and mark-recapture data have been collected throughout the history of this population. This unique data set allows us to document the effects of genetic drift and gene flow on the genetic diversity of this population over time. Preliminary results have been generated using microsatellite markers. Prior to the initiation of prescribed burns, results indicate low gene flow among glades as well as a decline in genetic diversity. For the years following these burns, we begin to see increased gene flow and a rise in genetic diversity. These data highlight the importance of landscape level habitat restoration for maintaining the genetic integrity of populations.

***NEUMANN, DANIELLE; DICKSON, KATHRYN**

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Comparison of digestive enzyme activities in tunas and their ectothermic relatives

Tunas are known to elevate the temperature of their aerobic locomotor muscle, and some tuna species can also maintain elevated visceral temperatures. Tunas are effective predators, swim continuously, and have high metabolic rates. Their diet consists primarily of large quantities of protein and lipids. In tunas, the largest visceral organ is the caecal mass, which is thought to increase the surface area for digestion and absorption. This study is a comparison of digestive enzyme activities in tunas and their close ectothermic relatives, to test the hypothesis that enzyme activities are greater in the endothermic tunas. Two tuna species [yellowfin tuna (*Thunnus albacares*), a species that warms its muscle but not its viscera, and albacore tuna (*Thunnus alalunga*), a species that warms both the muscle and viscera] were compared with the ectothermic chub mackerel (*Scomber japonicus*) and eastern Pacific bonito (*Sarda chiliensis*). The specific activities of pepsin in the stomach and lipase in the caecal mass and intestine will be measured at 15°C and 25°C and trypsin in the intestine and caecal mass will be measured at 20°C and 25°C, with spectrophotometric assays. It is predicted that the caecal mass of endothermic species will exhibit higher digestive enzyme activities than that of non-endothermic species. High enzymatic activities in the caecal mass will support its importance in digestion. If enzymatic activities are significantly higher in the endothermic albacore at its elevated visceral

temperature, this would suggest elevated visceral temperatures is likely to speed up processes of absorption and digestion.

NG, HEOK HEE

Fish Division, Museum of Zoology, University of Michigan, 1109 Geddes Ave., Ann Arbor, MI 48109-1079, USA

Phylogenetic relationships of the erethistid catfishes (Teleostei: Siluriformes)

The phylogenetic relationships of the Erethistidae, a group of South Asian hillstream catfishes, are examined utilizing evidence from a combination of morphological and molecular characters. The diversity of the group is briefly reviewed. *Erethistes* and *Hara*, as currently defined, are not hypothesized to be natural groups. The results of this study corroborate some of the results of an earlier study by de Pinna, i.e. *Conta* is hypothesized the sister group of all other erethistids. However, other hypotheses of erethistid relationships of de Pinna are not corroborated: the clade consisting of *Erethistoides*+an unnamed genus+*Caelatoglanis* is hypothesized to be the sister group of *Pseudolaguvia* (and not *Erethistes*+*Hara* as postulated by de Pinna). New synapomorphies diagnosing subgroups of erethistids are identified in this study. The biogeographic implications of this study, as well as the evolution of the thoracic adhesive apparatus within the group are also briefly discussed. **STOYE GENERAL ICHTHYOLOGY**

***NGUYEN, ROSALEE M.; CROCKER, CARLOS E.**

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The effects of different substrates on foraging behavior and growth rate of larval Green Sturgeon, *Acipenser medirostris*

We investigated the effects of substrate composition on foraging behavior and growth rate of larval green sturgeon, *Acipenser medirostris* at 20±1°C. Larval groups (n=100; mean wet wt., 0.72 ±0.01g at 50 days post-hatch) were reared on rocks, cobble, sand or glass, and each group was video recorded for 45 min. (15min pre-feed and 30min. feeding) for 5 weeks. Each aquarium was supplied with one of the following substrates: rocks (dia.< 163mm), cobble (dia.< 52mm), sand (dia.< 2.5mm) or nothing (bare bottom). Fish were fed 5% bwt day-1, allowed 1 week to acclimate to their new tank conditions, and were exposed to a 12L:12D photoperiod. Typically, fish were negatively rheotactic and exhibited dispersed skimming behaviors on substrates during pre-feeding and feeding periods, but were positively rheotactic during feeding. Fish reared on rock substrates were strongly photonegative, remained benthic, and aggregated underneath the rocks. In all substrates (except rock), fish displayed frequent episodes of burst/ glide swimming activity, tank wall skimming and vertical swim-up behavior, but these behaviors ceased during feeding and reappeared at the end of the feeding period. Substrate composition led to variable foraging effectiveness and likely contributed to significant differences in specific growth rates (SGR, 2.28%, 1.14%, 1.77%, and 2.27% b/wt d-1) and mortality (7%, 43%, 11%, 0%) among the treatment groups; rocks, cobble, sand, and glass,

respectively. Total length, fork length, dorsal fin length, cranial diameter and the number of scutes were measured bi-monthly in a sub-sample (n=10) from each treatment group; different substrates did not significantly affect morphological development. Whole-body lipid content analyses performed on a sub-sample (n=5) from each treatment group at the end of 5 weeks were not significantly different. The present findings indicate that certain substrates in artificial/natural habitats may negatively affect larval growth and may lead to decreased recruitment of juvenile green sturgeon in the wild.

***NICHOLS, BRYAN; MANN, DAVID**

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Characterizing sound production in nearshore Rockfish (*Sebastes* spp.)

Rockfishes (*Sebastes* spp.) are the dominant predators over many nearshore habitats from California to Alaska. The genus contains close to seventy species, including one that lives over 200 years. They are the target of large commercial and recreational fisheries, and their numbers have dropped catastrophically over much of their range. Numerous rockfish species have been shown to have sonic muscles on their swimbladders and divers have reported hearing grunts from several species at least. Considering the economic importance of the various rockfish fisheries and the threatened status of many populations, there is a surprising lack of information on sound production and reproduction. Incorporating unpublished studies and data with new technology, field and lab work, this paper will characterize the burps, pops and growls of nearshore rockfishes and determine whether species can be distinguished by their calls.

***NICHOLSON, CHERYL H. Z.; LAWRENCE, ANDREW, J.; GIBSON, DAVID.**

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Captive mating in sand tiger sharks (*Carcharias taurus*)

Mating of sand tiger sharks (*Carcharias taurus*) was observed and filmed at the Blue Planet Aquarium, Ellesmere Port, England, in May of 2004. The shark tank where the 5 sand tigers are kept is an irregular polygon approximately 25 meters wide, 36 meters long, averaging 3 meters in depth, and with a maximum depth of 6 meters. The tank holds 2.8 million liters of water with the whole system containing 3.8 million liters. Water is heated to mimic natural conditions with a minimum water temperature of 22°C and a maximum temperature of 26°C. On May 3rd a 240 cm male sand tiger was observed courting a 270 cm female. The male followed the female then nosed her, coming from behind and underneath the female, and placing his snout just below the cloaca. The initial bite was to the right pelvic fin of the female. The pair then spiraled in a clockwise direction for 14 seconds with the female shark trying to bite the male. His grip held and he remained out of her reach so was not bitten. The female then submitted. Still biting her pelvic fin the male slowly swam them both around the tank and worked his grip up to the right pectoral fin. This lasted 1 minute. The female was

then turned onto her back as the male inserted his right clasper into her cloaca. The male was also upside down during copulation, which lasted 32 seconds. After the male withdrew, he swam off with his claspers crossed. The female remained in the bottom of the tank for twenty-four minutes before turning herself into an upright position and swimming off. Mating of sand tigers in the wild has not been observed, and to our knowledge this the only time when such behavior has been filmed in captivity.

***NICKERSON, M.A.; BRIGGLER, J.T.**

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Harvesting as a factor in population decline of a long-lived salamander, the Ozark hellbender, *Cryptobranchus alleganiensis bishopi* Grobman.

We documented the harvesting of 573 Ozark hellbenders, *Cryptobranchus alleganiensis bishopi*, between 1969 and 1989, from North Fork of White River, Ozark County, Missouri. Scientific studies accounted for 253 individuals. More than 256 individuals were taken for the pet trade for suppliers in Michigan, New Jersey, and Japan by collectors from Nebraska and Alabama. One hundred seventy one were illegally removed during the 1980 Labor Day weekend. Estimates indicate that about 50% of the females were removed from one of the most significant habitats in NFWR that weekend. Between 1969 and 1980 coordination with the Department of Conservation helped insure that *C. a. bishopi*, used in scientific research, were not removed from a 2.67 km research section. Population estimates from 1969 and 1978 studies indicate stability in the most densely populated habitat. In the 1970's larger samples harvested for research were not removed from a single site, but a few were collected from multiple sites within about 10 kms of the river. During 1982-1983 more than 100 individuals were removed from the same section of NFWR as in 1980 by commercial collectors. This evidence supports harvesting of *C. a. bishopi*, especially illegal harvesting, as a substantial factor in the decline of this Ozark hellbender population and documents that the decline began by 1980.

***NICO, LEO G.; JELKS, HOWARD L.**

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Probable establishment and potential ecological impacts of Black Carp (*Mylopharyngodon piceus*) in U.S. waters

The Black Carp *Mylopharyngodon piceus*, native to eastern Asia, is one of several commercially important fishes often referred to as the Chinese or Asian carps (Cyprinidae). It is a large fish, often exceeding 1 m SL. Maximum size is about 2 m TL and 70 kg. Black Carp typically inhabit big rivers and associated backwaters. Adults are morphologically adapted for feeding on mollusks, being armed with large, crushing teeth mounted on large, well-muscled pharyngeal jaws. In the USA, Black Carp were not generally known outside aquaculture circles until the early 1990s. Concern was expressed that escaped fish would feed

on native imperiled snails and mussels. In 2003 and 2004 it was reported that commercial fishers netted Black Carp from a few sites in the middle and lower Mississippi River. These isolated captures were thought to be the first US records of Black Carp in the wild, but new information indicates that the species has been periodically taken by commercial fishers in open waters of the lower Mississippi since the early 1990s. These earlier captures went unreported as fishermen mistakenly believed the fish were simply an unusual "Grass Carp". Reproductive requirements of Black Carp are similar to three other Chinese carps (Grass Carp, Bighead Carp, and Silver Carp) already established in the Mississippi Basin. Given new information indicating Black Carp have been in the wild more than 10 years and that suitable conditions for the species' entire life cycle exist (i.e., spawning and nursery areas, food resources, etc.), it is probable that Black Carp are reproducing and established. If Black Carp follow the same patterns of spread and colonization as other introduced Chinese carps, the distribution and abundance of wild Black Carp will increase over the next several years. Because of their size and diet specialization, presence of wild Black Carp in North American may hasten the decline of native mollusks. Analysis of Black Carp gape limits suggests many mollusks will be vulnerable to predation.

***NIEMILLER, MATTHEW L.; MILLER, BRIAN T.**

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Distribution, relative abundance, and notes on the natural history of the Tennessee Cave Salamander complex (*Gyrinophilus palleucus*) in Tennessee

The Tennessee Cave Salamander complex consists of two troglobitic species, the Tennessee Cave Salamander (*Gyrinophilus palleucus*) and Berry Cave Salamander (*G. gulolineatus*). As part of an ongoing project to determine the status and relative abundance of populations of the complex in Tennessee, historic and potential localities were surveyed from June 2004 through March 2005. Three hundred eighty *G. palleucus* and *G. gulolineatus* were observed in 16 of 44 caves surveyed in Coffee, Franklin, Grundy, Knox, Roane, Rutherford, and Warren Counties. Of the 380 Tennessee Cave Salamanders observed, 266 were captured yielding a 70% capture rate. Metamorphosed and large (> 75 mm SVL) larval *Gyrinophilus* were found syntopically at one cave in Knox County. However, the relationship between these two forms has yet to be resolved. Extant populations of the *G. palleucus* complex were confirmed at two caves in the Central Basin, two caves on the Eastern Escarpment of the Cumberland Plateau, one cave on the Western Escarpment of the Cumberland Plateau, and four caves in the Ridge and Valley Physiographic Province. Six new populations were located on the Eastern Highland Rim of Warren County (3 caves) and Western Escarpment of the Cumberland Plateau (3 caves). Four or fewer salamanders were observed in most caves. However, 19 or more individuals were observed in six caves. Jolly-Seber mark-recapture data estimated over 230 individuals at one cave in Grundy County. Adults (> 70 mm SVL) dominated each of the populations, but larvae and juveniles were found at most caves, indicating that reproduction was occurring.

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Low hatching success of gopher tortoise eggs in Mississippi is due to egg quality and the nest environment

This study focuses on gopher tortoise hatching success in DeSoto National Forest, one of the last strongholds of this species in the western portion of its range. Previous studies have found low recruitment here, due in part to low hatching success of tortoise eggs. The objective of this study is to determine the causes of this low hatching success. In 2002 and 2003, hatching success was compared between eggs that were artificially incubated and those incubated under natural conditions. The success rate for laboratory incubated eggs was approximately 60% in both years, compared to hatching success of 6% (2002) and 16.7% (2003) for eggs that remained in natural nests. This suggests that 60% were capable of successful development, while as many as 40% of the eggs had intrinsic problems. The low hatching success in nests implies unsuitability of some aspect(s) of the nest environment. Consequently, aspects of the nest environment were quantified to search for a correlation between environmental factors and hatching success. Multivariate analysis revealed that nest temperature and clay content of the soil were most strongly correlated with hatching success. The relationship between these environmental factors and hatching success was experimentally examined in 2004, by artificially incubating eggs under three thermal regimes and in substrates of low or high clay content soil, based on the nest parameters monitored in 2003. There were no significant differences in hatching success for eggs incubated in the three temperature treatments or in low and high clay content soils, and there was no significant interaction between clay content of the substrate and incubation temperature. Thus, while incubation temperature and substrate clay content were associated with low hatching success in nests, experimental incubation revealed that the factors we used are not directly, or solely, responsible for the failure of eggs to hatch. **SSAR SEIBERT CONSERVATION**

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Diagnosing *Batrachochytrium dendrobatidis* in amphibian populations from the Ecuador - Peru Border

Ecuador is currently considered one of the world's megadiverse countries. Since the 1980s, amphibian populations have nonetheless declined in the Ecuador, especially those in High Andean ecosystems and Jambato (such as *Atelopus ignescens*). Populations of *Telmatobius vellardi* and *Bufo amabilis* also have declined in association with climate change and the presence of fungus *Batrachochytrium dendrobatidis* (BD). This study aimed to characterize the effects of the fungus BD in the southern Andean region of Ecuador. The study area is located in the Podocarpus National Park and its zone of influence. Sampling was performed from 2001 to 2004, within ecosystems located

approximately 2000 meter above sea level. The Visual Encounter Survey (VES) methodology was used to sample each area. Collected material was taken to the laboratory, where digits and dermal flap tissues were sampled. Tissues were analyzed via histological skin preparations adapted from Drudy and Wallington (1980). During our field work, we also registered dead individuals in Dr. Servio Aguirre Protected Forest. Tissues from these individuals are currently being analyzed together with those from all other amphibian populations sampled. A total number of 111 individuals were collected for the project, belonging to the families Leptodactylidae, Hylidae, Centrolenidae, Bufonidae, and Dendrobatidae. **SSAR SEIBERT CONSERVATION**

OBERHOFER, LORI; *SNOW, RAY W.

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Disposable pets, unwanted giants: Pythons in Everglades National Park

Reports of exotic snakes in Everglades National Park include regular and increasing sightings of Burmese pythons (*Python molurus bivittatus*). Pythons in the wild today are a result of unwanted, intentionally, and perhaps accidentally, released exotic pets. Pythons have been observed along the main park road, in Long Pine Key, at Shark Valley, along Tamiami Trail, on the eastern park boundary, along canal levees, and in the remote mangrove backcountry. In recent years more than 125 Burmese pythons have been removed from the park or adjacent lands. The non-native python's diet in the Everglades includes gray squirrel, opossum, cotton rat, black rat, rabbit, house wren, pied-billed grebe, and white ibis. Sources of mortality include motor vehicles, mowing equipment, fire, and possibly alligators. Multiple observations of individuals of different size-classes support the probable establishment of breeding populations of the Burmese python in Everglades National Park. The measured total length for snakes recovered ranged from 65 cm to 427 cm, including five hatchling sized animals recovered in the summer of 2004. Burmese pythons are widely bred in Florida and still imported from Southeast Asia. Proposed management actions must include strategies for preventing their intentional and accidental release. Some of the actions currently being undertaken by the park include: (1) preparing and distributing an exotic snake alert flyer and prevention materials based on a - Don't Let It Loose - media campaign to encourage responsible ownership and proper disposal of unwanted exotic pets; (2) summarizing information on all observations and specimens of pythons from the park; (3) researching available information on life history, behavior, home range, food habits, etc., as observed in their native habitat, (4) investigating methods of capture, restraint and disposal, including the use of snake detecting dogs, and (5) investigation of predictive risk assessments for similar species in the exotic pet pathway.

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Meta-analysis of estuarine fish assemblage data using a new taxonomic-based method

In the past, taxonomic approaches were rarely used in conjunction with ecological efforts to assess the relative health of fish assemblages among different ecosystems. We present results of a new method for assessing fish assemblage health among different estuarine ecosystems in coastal Louisiana. Comparing multiple regions often involves combining information from separate studies. These "meta-analyses" allow for comparisons of relative ecological health among different ecosystems. We analyzed fishery-independent trawl data from four estuarine regions: the Barataria Basin, Lake Maurepas, Lake Pontchartrain, and the Biloxi Marsh/Chandeleur Islands region. To determine the relative health of fish assemblages in these regions, we calculated average taxonomic distinctness (+) and variation in taxonomic distinctness (+) for 3511 trawl collections and compared each sample value to 1000 random values generated from a master species list. This robust, recently-developed analytical approach is not dependent on sample size or effort and includes a framework for measuring departure from expected values. When the regions were compared, Lake Pontchartrain (an oligohaline estuary adjacent to New Orleans) had significantly more samples with reduced + than expected (observed $2 = 12.1$, $p = 0.001$), suggesting it is the most impacted ecosystem.

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Estuarine habitats as possible corridors for the dispersal of freshwater invasive fishes

While there is substantial evidence that some freshwater fishes can survive brackish or saline habitats, only recently has this phenomenon been linked to problems with invasive species. Recent worldwide evidence suggests that freshwater invasive fishes regularly occur in estuarine habitats and may pose an unexpected threat to native estuarine species. For example, the Rio Grande cichlid, *Herichthys cyanoguttatus*, has become established in the canals of New Orleans, Louisiana, USA. These aquatic habitats are connected to Lake Pontchartrain, an oligohaline estuary. A diffusion model of the expansion of *H. cyanoguttatus* supported the possibility that estuarine habitats were being used by this introduced freshwater fish as corridors for expansion. Subsequent field surveys found both adult and juvenile *H. cyanoguttatus* in salinities ranging from 0 to 5 ppt. This and other evidence suggest that *H. cyanoguttatus* may not only survive movement through estuarine conditions, but may also be capable of becoming established in these habitats. Preliminary accounts of other introduced freshwater fishes (e.g., the silver carp, *Hypophthalmichthys molitrix*, in the lower

Mississippi River) suggest similar scenarios occur throughout the world. Implications from these findings suggest that: 1. no assumptions should be made about the effectiveness of estuaries as barriers to the expansion of introduced freshwater fishes and 2. native estuarine fish species may not be immune to negative impacts associated with freshwater invasive fishes.

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Histological comparison of the retinal structure of deep-water and epipelagic sharks

Morphological characteristics of the retina of a deep-water shark of the order Squaliformes were compared to three epipelagic sharks (one carcharhinoid and two lamnoids) to investigate visual adaptations in elasmobranchs living at different depths. The three epipelagic species (*Alopias vulpinus*, *Isurus oxyrinchus*, and *Prionace glauca*) have well-developed eyes, with retinas composed of both rod and cone photoreceptors in ratios of 13:1, 12:1, and 14:1, respectively, whereas *Centrophorus cf. uyato*, a mesobenthic species found at depths greater than 400 m, has a retina composed solely of rods. The rod-rich, relatively cone-poor retinas of these four elasmobranchs yield low visual acuity and rather high sensitivity, enabling them to detect an object against contrasting background in dim light. Further histologic investigations into eight different regions of the retinas, four central and four peripheral, exhibited no indication of intraretinal variation within each species in terms of photoreceptor abundance, distribution, outer-segment length, inner-segment length, or width, suggesting that there is no specific area of increased visual acuity or sensitivity in the photoreceptor layer of these species. As expected, interspecific variation in these characteristics was observed between the deep-water squaloid and the three epipelagic sharks, whereas little variation was observed between the ecologically and taxonomically related *A. vulpinus* and *I. oxyrinchus*. These variations in retinal structure are discussed in terms of the ecological and taxonomic relationships of these sharks.

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Molecular phylogeny of the superfamily Loricarioidea (Teleostei: Siluriformes)

The superfamily Loricarioidea, the largest siluriform clade of the Neotropical region, includes the families Trichomycteridae, Nematogenyidae, Callichthyidae, Scoloplacidae, Loricariidae and Astroblepidae. Morphological studies suggested that the families Trichomycteridae and Nematogenyidae belong to a monophyletic group, which is a sister group of the clade composed of the remaining families; the families Astroblepidae and Loricariidae form a monophyletic group, which is a sister group of Scoloplacidae, and these three families form a clade, which is a sister group of Callichthyidae. The African family Amphiliidae was hypothesized as the primitive sister group of

Loricarioidea. With the main objective of testing the hypotheses described above, the mitochondrial genes of both ribosomal RNA subunits (12S and 16S), the genes coding of two subunits of cytochrome c oxidase (COI and COII) and seven RNA transporters, totalizing eleven genes (5360 to 5399 base pairs), of ten species of Siluriformes, including representatives of Diplomystidae, Cetopsidae, Aspredinidae, Amphiliidae and all families of Loricarioidea, were sequenced. Although the different phylogenies obtained by the methods of maximum parsimony and maximum likelihood were not completely congruent, the monophyly of Loricarioidea, the monophyly of the clade composed of Amphiliidae and Loricarioidea, and the basal position of the family Trichomycteridae in relation to the other Loricarioidea were corroborated. On the other hand, the molecular data suggested the existence of a clade formed by families Loricariidae and Callichthyidae, which was the sister group of the clade composed of the families Scoloplacidae and Astroblepidae. The position of Nematogenyidae could not be established since it changed in the different analyses conducted. Considering the differences observed between the phylogenies obtained with morphological and molecular data, it is possible to conclude that the data enlargement (molecular and morphological) will be fundamental to a better understanding of the relationships between the families of Loricarioidea.

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Reserva Amazonica, Peru: Amphibian population monitoring and ecotourism

Loss of biodiversity, particularly amphibians, is a global concern illustrated by numerous threatened species in Latin America, the most species diverse area of the world, and the importance of amphibians as indicators of ecosystem health (Global Amphibian Assessment, Duellman and Koechlin 1991). Long-term monitoring of species occurrence, abundance and local distributions is continuing at Reserva Amazonica, Peru, a research and tourist center. The first objective involves monitoring amphibian populations over time following the Neotropical Biological Diversity Program (BIOTROP) established in 1988. Amphibians were collected by researchers conducting systematic searches, both during the daylight and at night in the permanently marked quadrat and trail system. Data collected from all observed animals included quadrat number, association with permanently numbered tree, height above ground, date, hour and activity. Results will be combined with previous data to obtain a long-term perspective on amphibian populations. The second objective is to contribute materials and projects to Reserva Amazonica intergrating research and tourism. In collaboration with the local biologist, revisions to current educational materials will be made, including multimedia presentations with photographs, natural history descriptions and maps illustrating areas tourists are likely to observe each particular amphibian species. Interactive research projects involving common species such as *Ceratophrys cornuta*, *Epipedobates hahneli* and *Colostethus marchesianus* will be developed. Tourists will be encouraged to gain knowledge for themselves by participating in data collection for the researchers. Financial support from tourist activities will then be used to support local community improvements reducing the dependency on more environmentally destructive development.

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Systematics of *Sebastes aleutianus*: Molecular and morphological evidence for a new species of rockfish from Alaska

As presently recognized, *Sebastes aleutianus* Jordan and Evermann, the Rougheye Rockfish, ranges from the Kuril Islands in the western Pacific to southern California, mainly on the continental slope and outer shelf at depths to 750 meters. Using starch gel electrophoresis, 1,027 rougheye rockfish were analyzed for variation at 29 protein-coding loci. This analysis revealed two evolutionary lineages that exist in sympatry with little or no gene flow between them. When analyzed as two distinct species, neither lineage exhibited heterogeneity among regions. Morphological data taken primarily from nearly 150 genotyped specimens will be presented and taxonomic implications discussed in light of these genetic differences. Geographically, the southern species, which we refer to *S. aleutianus*, ranges in our collections from California north through the Gulf of Alaska into the southern Bering Sea and eastern Aleutian Islands. The northern, and probably new, species ranges from Kamchatka along the Aleutian Islands and Bering Sea slope, to as far south as the Washington coast. It is sympatric and often syntopic with northernmost populations of the southern species in the eastern Aleutians and southern Bering Sea, and throughout the Gulf of Alaska to Washington. The distribution of the two species may also be strongly correlated with depth. The southern species is typically paler in body color, occurring more abundantly in shallower waters, while the darker northern species is more abundant in deeper waters. Aspects of North Pacific zoogeography will be discussed in light of our conclusions.

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Phylogeny of the ray-finned fish (Actinopterygii): Analysis of more than 500 RAG-1 exon 3 sequences

The coding sequences corresponding to exon 3 of the recombination activating gene 1 (RAG-1), approximately 1500 bp, have recently become established as a molecular marker for vertebrate phylogenetic studies. We present the first results obtained with this marker for a comprehensive data set of actinopterygian fishes. Together with mitogenomic analyses undertaken by Miya, Nishida, and colleagues, these data sets constitute the first attempts at obtaining a global phylogenetic tree for actinopterygian fishes based on explicit cladistic methodology. We present results of a diverse array of analyses, including maximum parsimony, maximum likelihood, and Bayesian approaches. Given that the RAG-1 sequences exhibit pronounced base compositional differences at third codon positions among taxa, different analytical strategies are presented to avoid systematic bias in the resulting trees. A subset of the taxa, with complete mitochondrial genome sequences, is used to compile a multi-locus data set for analysis. Critical evidence supporting the traditional and novel sister group relationships is identified in each data partition and a combined analysis (total evidence) is used to highlight the potential of these molecular markers and analytical approaches for studying fish phylogenies at a large scale. This collaborative effort is a major advance for the field but underscores the need to develop many more nuclear gene markers to help establish a well-supported phylogenetic hypothesis for actinopterygian fishes.

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The phylogeny of the Gerreidae (Teleostei: Percoidei)

The family Gerreidae is distributed along the sea coasts of most tropical and the warmer temperate regions of the world. Relationships among genera are investigated based on cladistic analysis of adult and early life history characters. The ingroup was one species of each genera; three genera are amphiamerican *Diapterus peruvianus*, *Eugerres axillaris*, and *Eucinostomus dowii*, one American and Indo-Pacific region *Gerres cinereus*, one of the West Atlantic *Ulaema lefroyi*, another of the Indo-Pacific *Pentaprion longimanus* and one of temperate Australia *Parequula melbournensis*. The out-group was integrated for species of three genera, representatives of families related to the gerreids *Lobotes pacificus*, *Lutjanus peru* and *Paralabrax maculatofasciatus*. The data matrix included 64 characters. The polarization was made for an out-group method and for the ontogenetic evidence. The reconstructions of the tree in the exhaustive search and five equally parsimonious trees were obtained (186 steps, IC = 0.903; IH = 0.097; IR = 0.772; ICR = 0.697); 13 characters were not informative to the Parsimony and they were ignored. When using the method of strict consent, a tree was obtained that showed an unresolved polytomy with the taxa; *Lobotes*, the clade of *Gerres*, *Eucinostomus*, *Ulaema*, *Eugerres* and *Diapterus*, and *Pentaprion* and *Parequula*, which are poorly resolved by hypotheses. We use the method of safe taxonomic reduction to exclude *Parequula*, which contributes the least information. When running the data again, we obtained the tree that explains the phylogenetic relationships of the Gerreidae. The hypotheses that are reflected according to the evidence are that the *Lobotes* persist as the sister group of the gerreids. All the gerreid genera except *Pentaprion* constituted the monophyletic subfamily Gerreinae. In this clade, *Gerres* is the near ancestry and *Ulaema* the generic group more derived.

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A DNA investigation into the origin of Saluda River *Micropterus coosae*: An introduced or native population?

Redeye bass (*Micropterus coosae*) are native to the southeastern United States in both Gulf and Atlantic Slope drainages, extending east from the Mobile River through the Apalachicola, Altamaha and Savannah River drainages to the upper portion of the Santee River drainage. There has been considerable debate over whether or not South Carolina's Saluda River population in the Santee is really native or translocated. We present the results of our DNA sequence data and

report the most likely explanation for the presence of Saluda River *M. coosae*.

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Metabolic response to feeding for boas and pythons

The wide regulation of metabolic and digestive performance to feeding and fasting experienced by Burmese pythons (*Python molurus*) is considered a physiological adaptation to their infrequent feeding habits. Burmese python possess low standard metabolic rates (SMR) which increase dramatically after feeding. The magnitude of their postprandial metabolic response is largely dependent on meal size, increasing with larger meals. To explore the generality of this metabolic response among boas and python, we have measured the metabolic rates of three boid species, boa constrictor (*Boa constrictor*), rosy boa (*Lichanura trivirgata*) and the green anaconda (*Eunectes murinus*) and of four pythonid species, blood python (*Python brongersmai*), African rock python (*P. sebae*), reticulated python (*P. reticulatus*), and Burmese python following their consumption of rodent meals equaling 25% of snake body mass. In addition, we have compared the metabolic response to three meals size (5%, 15%, and 25% of body mass) for the green anaconda, blood python, African rock python, reticulated python, and Burmese python. In response to meals 25% of body mass, metabolic rates of snakes peaked between 8 and 18-fold of SMR and remained significantly elevated above SMR for 5 to 9 days. The accumulated cost of digesting and assimilating these meals, their specific dynamic action (SDA), ranged between 344 and 670 kJ/kg. With a decrease in meal size, peak postprandial metabolic rates declined to 6 to 8-fold of SMR and 4 to 5-fold SMR, respectively for the 15% and 5% size meals. The smaller meals also generated a smaller SDA, averaging 210 and 65 kJ/kg, respectively, for the 15% and 5% size meals. These boas and pythons exhibit similar large increases in metabolism with feeding and a correlated reduction in digestive costs with smaller meals.

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Climatic variation and the distribution of the gray treefrog complex

Formation and establishment of sexually reproducing polyploid populations involves the ecological aspects of persistence and growth of the polyploids in the presence of the progenitor species. Theories concerning the ecological aspects of establishment of polyploid populations often focus on niche separation and use of habitats not occupied by the diploid progenitor; often habitats used by polyploid populations are considered more environmentally severe. We tested the application of niche separation to a diploid-tetraploid species pair of gray treefrogs, *Hyla chrysoscelis* and *H. versicolor* (Anura; Hylidae), by investigating relationships among the distributions of gray treefrogs, climatic variation and associated elevation variation across the mid-Atlantic region of Eastern North

America. Calling surveys at wetland breeding sites throughout Virginia and Maryland were used to document the distribution of each species. We generated 12 climatic models and one elevation model to predict climatic and elevation values for gray treefrog breeding sites. Results from a canonical analysis of discriminants (CAD) suggest a strong correlation between several climatic variables, elevation and the distribution of the gray treefrog complex. Specifically, the polyploid species (*H. versicolor*) almost exclusively occupied the higher elevation, northwestern portions of the study area where climatic conditions were more severe (colder, drier, and greater climatic variation). In contrast, the diploid species (*H. chrysoscelis*) was restricted to the lower elevation, southeastern portion of the study area where climatic conditions were less severe. Clusters of syntopic sites were found along a line of sympatry located in the Piedmont physiographic province and were associated with areas of high variation in annual temperature and precipitation during the breeding season. Our data suggest that physiological changes associated with the polyploid state of *H. versicolor* may allow it to utilizing habitats outside the niche of *H. chrysoscelis* and, at least partially, be responsible for *H. versicolor* population persistence.

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Effects of the invasive Cuban Tree Frog in the British Virgin Islands.

The Cuban tree frog, *Osteopilus septentrionalis* (CTF), is currently invasive in Florida, Hawaii, Puerto Rico, Anguilla, Bonaire, the US Virgin Islands, and most recently, the British Virgin Islands (BVI). Our research involves the invasive CTF populations in the BVI and has three primary objectives: first, document the spread of the CTF in the BVI; second, identify the diet of the CTF in the BVI; and third, detail reproductive ability and output of the CTF in the BVI. We have obtained over 400 CTFs, collected from five islands in the BVI. CTF distribution within the BVI is expanding, with three of the five islands on which they are currently found, infected within the past two years. The diet of the CTF in the BVI is significantly different than that reported from Florida, supporting the idea of dietary plasticity. Stomach and intestinal contents include spiders, scorpions, insects, native frogs, geckos, and snakes. Data on the reproductive readiness of both males and females and on clutch size show that both sexes possess year round reproductive ability. Together, these findings help explain the success of the CTF in invading new habitats and indicate a growing impact on the local ecosystem. Data collected will be used to predict future colonization patterns and make further management recommendations. **SSAR SEIBERT CONSERVATION**

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Courtship calls in two species of chorus frogs, genus *Pseudacris*

We studied the courtship behavior of two species of chorus frogs, *Pseudacris illinoensis* and *P. triseriata*, in western Illinois. We report observations of courtship behavior and describe courtship calls for each species. These calls were given in response to both male and female conspecifics entering the territories of resident males. Courtship calls given in response to an intruder were never followed by aggressive behaviors from the resident or the intruder, and courtship calls were never given in response to playbacks of conspecific advertisement calls. Thus, these calls do not seem to be used in an aggressive context. Courtship calls of *P. illinoensis* are longer in duration and lower in dominant frequency than advertisement calls. Courtship calls in *P. triseriata* consist of multiple notes compared to single note advertisement calls, and they have faster pulse rates. These courtship calls are given at faster calling rates than advertisement calls, and there is a tradeoff between calling rate and call length. Courtship calls of both species are more variable in structure than advertisement calls. Like two other species of chorus frogs for which courtship calls have been reported, courtship calls in *P. illinoensis* and *P. triseriata* are direct modifications of the advertisement call. Courtship calls in the genus that have been described so far do not appear to share a common structure.

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Coarse woody debris and herpetofaunal communities: a manipulative study

Coarse woody debris (CWD) may be an important component in controlling diversity and abundance of organisms. Because it can be manipulated by forest managers, understanding the ecosystem functions of CWD is critical so that species that use it can be managed for properly. Correlative studies suggest that some species of herpetofauna respond positively to the presence of CWD, although the extent to which CWD affects these communities is not fully understood due to a lack of manipulative studies. The purpose of this study was to manipulate standing and downed volumes of CWD to determine the response of reptile and amphibian communities. The four treatments of interest were downed, where CWD volume was increased on the ground; removal, where CWD on the ground was removed; snag, where the number of standing dead trees was increased; and control, where CWD volume was not manipulated. Sampling was conducted seasonally from October 2003 through October 2004. I analyzed reptile and amphibian species abundance, richness, and diversity among treatments and seasons using a 2-way completely randomized block ANOVA. The only species of herpetofauna that exhibited a positive response to the presence of CWD was the southern toad, which was found more frequently in the downed treatment than the other treatments in the summer. Sampling will continue through fall of 2005, possibly yielding stronger treatment effects as the

CWD becomes more decomposed, and therefore more suitable as habitat for herpetofaunal communities. **SSAR SEIBERT CONSERVATION**

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Second edition of Peterson Field Guide to Freshwater Fishes, Part II:
What it tells us about fish taxonomy

An analysis of information in the 2nd edition of the *Peterson Field Guide to Freshwater Fishes of North America North of Mexico* provides data on the types of characters that are used to diagnose North American freshwater fishes, and how these types vary among groups of fishes, and how they vary geographically and ecologically. We will analyze how taxonomists use this information and why additional populations are being recognized as species.

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FSH- and LH-expressing cells during development of the cichlid fish
Cichlasoma dimerus: Novel expression of gonadotropins in brain and ovary

Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) expressing cells were detected in pituitary, brain and ovary of the cichlid fish *Cichlasoma dimerus* (Perciformes, Acanthopterygii). This detection was carried out by immunohistochemistry (IHC) and Western blot techniques, using antisera of *Fundulus heteroclitus* (Cyprinodontiformes, Acanthopterygii) against the conservative region of the FSH and the LH subunits. The estimated molecular weights, measured by SDS page and western blot were 24 kD for LH (pituitary, brain and ovary) and 19 and 15 kD (pituitary and ovary) and 15 kD (brain) for FSH. In the pituitary, both cell types showed a distribution along mid and ventral zones of the proximal pars distalis (PPD, mid-immunoreactive cells) and along the ventral and dorsal external border of the pars intermedia (PI, high-immunoreactive cells). Double IHC showed that FSH and LH are mainly expressed in different pituitary cells, with the exception of some co-localization observed on the ventral border of the PI. FSH cells were detected in the pituitary around day 21 after hatching (ah) (prior to sex differentiation), while LH cells were detected by day 60 ah (during the sexual differentiation period). FSH and LH neurons were localized in the hypothalamic nucleus lateralis tuberis and their fibers project through the ventral hypothalamus, preoptic area and neurohypophysis. FSH neurons differentiated at the same time that the pituitary FSH cells on day 21 ah, while LH neurons appeared on day 15 ah, days before

differentiation of LH pituitary cells. In the ovary, the ir- for both FSH and LH was restricted to the cytoplasm of previtellogenic and early vitellogenic oocytes. These results suggest that the functions of FSH and LH are beyond their well-known effect on gonads and it is possible that they may be related with hypophysotropic, neuromodulator functions (brain derived GtHs) and intraovarian communication (ovary derived GtHs).

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Has climate change affected the spawning chronology of the Lake Sturgeon (*Acipenser fulvescens*)?

Climate change has been shown to have affected the timing of many phenological events in the Midwest. Many species of Great Lakes fishes, including the lake sturgeon (*Acipenser fulvescens*), ascend tributary streams to spawn in the spring. This study was prompted by a comparison of newspaper accounts of sturgeon catches in the Fox River below the De Pere dam (Brown County, Wisconsin) in the late 1800s-early 1900s with modern sightings at the same locality. Seasonal distributions were similar but peaked later in the spring during the historical period. The difference was greater than would be accounted for by a lag time in the publication of the newspaper accounts. Additional data on spawning times of sturgeon throughout the Lake Michigan basin were collected by surveying old newspapers (1860-1915) in towns and cities along major tributaries. Because spawning times differ among at least some localities within the same year, latitude was considered as a covariate. Although some localities showed evidence of a seasonal shift in the direction expected, others did not. Evidence for a historical shift in spawning phenology was generally stronger for drainages in Wisconsin than for those in lower Michigan, perhaps because the latter is more buffered by the effects of adjacent bodies of water.

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Variations in the response of gastric acid secretion during periods of fasting between shark species

Elasmobranchs are the earliest known vertebrates to develop an acid secreting stomach and also exhibit a variety of foraging modes. Inter-specific differences in the response of gastric acid secretion during periods of fasting are thought to exist amongst elasmobranchs, although the causative factors behind these differences are unknown. We have measured gastric pH continuously, using autonomous pH data-loggers, in free swimming leopard (*Triakis semifasciata*),

nurse (*Ginglymostoma cirratum*), and blacktip reef sharks (*Carcharhinus melanopterus*) and found that leopard and blacktip reef sharks continuously secrete gastric acid, while nurse sharks periodically cease acid secretion while fasting. Measurements of acid secretion rates, pepsin levels and a mathematical model of gastric digestion, suggest that maintaining a continuously acidic stomach may decrease digestion time of a subsequent meal by 5-7 hours in leopard sharks. We hypothesize that frequently feeding shark continuously secrete gastric acid as it provides antiseptic conditions, while reducing digestion time of a subsequent meal. Infrequently feeding sharks may periodically shut down acid secretion as an energy conserving mechanisms while fasting. **AES GRUBER**

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Habitat preferences of juvenile Winter Flounder, *Pseudopleuronectes americanus*, in the presence of structure

It is important to determine which habitats are utilized in the course of development for fishes, as habitat and survival are inherently linked. The majority of habitat preference studies for juvenile winter flounder focus on sediment size as a factor in abundance and growth, but few studies have investigated the importance of structured habitats such as cobble. I investigated in laboratory trials the habitat preferences of juvenile winter flounder in the presence of structure by using cobbles of varying coverage: 100% cobble, 50% cobble, 25% cobble, and 0% cobble (sand). Juvenile winter flounder were observed every half hour during the course of four, 8.5 hour trials. The results of these initial trials indicate a strong preference of the 50% cobble treatment to all other substrates (p-value .0001 from LSD), and a preference of structure to sand alone (a priori contrast, p<. 0001). I hypothesize that interstitial spacing is important in habitat choice for juvenile winter flounder, as reflected in the preference of the 50% cobble substrate. Future experiments will be conducted in the laboratory with artificial substrate and controlled interstitial spaces to test this hypothesis, and further investigate the significance of structured habitats to juvenile winter flounder. **STOYE ECOLOGY & ETHOLOGY**

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Reproductive morphology and evolution of viviparous poeciliid fishes (Teleostei: Atherinomorpha)

Atherinomorph fishes, comprising oviparous, ovoviviparous and viviparous taxa, have a unique type of testis in which spermatogonia are restricted to the distal ends of testis lobules, and an egg in which yolk is fluid rather than

granular. Internal fertilization and viviparity have evolved several times within atherinomorphs as interpreted from the parsimonious distribution of morphological and molecular characters, many of which are unrelated to reproduction. *Tomeurus* is an ovoviviparous poeciliid fish; internal fertilization is followed by females laying fertilized eggs. *Tomeurus* had long been thought primitive to the rest of the viviparous poeciliids until it was proposed as a close relative of the derived viviparous *Cnesterodon*. This relationship implied the unique reversal from viviparity to ovoviviparity in *Tomeurus*, a hypothesis we explore by examining a range of reproductive morphological characters. In *Cnesterodon* and *Tomeurus*, sperm are packaged in naked sperm bundles, or spermatozeugmata, that are similar in form to those of other poeciliids. Free sperm are stored in the ovary in both taxa. This is in contrast to oviparous atherinomorphs in which sperm are not packaged and not stored in the ovary. Efferent ducts in *Cnesterodon*, and other viviparous poeciliids, have a PAS + secretion indicating presence of a glycoprotein that keeps sperm inactive. This secretion is not PAS + in *Tomeurus* and oviparous atherinomorphs. *Tomeurus* shares reproductive characters with both oviparous and viviparous taxa as demonstrated by a comparison of these characters among a selection of atherinomorph taxa.

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Interpopulation variation of spatial learning and telencephalon shape in Threespine Stickleback Fish (*Gasterosteus aculeatus*)

There is strong evidence that fish possess spatial learning abilities and underlying neuroanatomical structures comparable to tetrapods. In tetrapods, larger hippocampal size is often correlated with superior spatial cognition. Similar size differences due to spatial learning may occur in the corresponding brain structure in fish (telencephalic dorsolateral region, Salas *et al.*, 2003). We addressed this question using the threespine stickleback fish (*Gasterosteus aculeatus*). These fish are primitively marine or anadromous (sea-run) species. In Alaska, anadromous populations established numerous resident lake populations post-glacially. Although most populations are generalist feeders, some are specialist planktivores (limnetics) or bottom feeders (benthics). Limnetics likely use mathematical algorithms to forage. In contrast, benthics, which live in more structurally complex habitats, feed on larger invertebrates that have stable locations within substrates. Therefore, benthics are more likely to use spatial foraging strategies. We tested nature-nurture differences in lab-reared stickleback from one benthic and one limnetic population for the ability to use visual cues to solve a maze. Benthics completed the maze significantly faster than limnetics. There was no significant effect of rearing (simple or complex) condition within populations, but limnetics reared in a spatially complex aquarium tended to complete the maze faster. A similar study using field-caught stickleback from different benthic and limnetic lakes resulted in a similar difference, but both field-caught populations solved the maze faster than lab-reared ones. Telencephalon morphology was also analyzed from one anadromous, five benthic, and five limnetic field-caught stickleback populations. We found that the dorsolateral region of the telencephala of benthic and

anadramous populations are more convex than that of limnetics. This result suggests that benthic and anadramous stickleback have more tissue mass in the dorsolateral region (relative to the rest of the telencephalon) than limnetics. However, interestingly, benthic stickleback do not have relatively larger overall telencephala than limnetics.

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Revealing greater complexity in rattlesnake chemical ecology: Change is in the air

Most species of rattlesnakes, if not all, release their prey following the venom-injecting strike and then engage in a modal action pattern called strike-induced chemosensory searching (SICS). Laboratory and field studies have shown that substrate cues play a central role in facilitating successful prey relocation during SICS, but no known studies have considered the importance of non-substrate chemical cues in the post-strike environment (i.e. airborne cues). Over the past three years, I examined rattlesnake (*Crotalus oreganus*) behavioral responses to a variety of airborne cues within a Plexiglas Y-maze. I found that rattlesnakes can use airborne cues from struck mice during SICS if substrate cues are absent, but the same snakes displayed a distinct preference for substrate cues if paired with airborne cues. When rattlesnakes followed airborne cues, they exhibited unique behavior patterns (long trailing times, numerous emergences, and turning behavior) that distinguished airborne trailing from substrate trailing. Second, rattlesnakes distinguished struck from unstruck substrate trails when presented with both simultaneously, but they did not make this distinction between struck and unstruck airborne cues. I concluded that airborne cues do not encode the same amount and/or type of information as substrate cues post-strike. Lastly, airborne cues led to successful trailing even when presented as air-deposited "fallout". Since airborne cues are multimodal (detectable either within the air column or once they settle out onto the substrate), airborne trailing could play a functional role in the chemical ecology of these snakes in situations where substrate trails are either unreliable (i.e. patchy trails from saltatorial prey) or absent (i.e. trails left by arboreal prey). My research has shown that rattlesnakes are not confined to using only substrate cues during SICS. Rather, substrate and airborne cues are both detectable post-strike, and, under given scenarios, they can both lead to successful relocation of struck prey. **STOYE ECOLOGY & ETHOLOGY**

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Oviductal oxygen availability as a physiological constraint on the evolution of viviparity in phrynosomatid lizards

Reptilian viviparity evolves through selection for increasingly prolonged egg retention within the oviduct. In the majority of lizard species, however, egg retention past the normal time of oviposition results in retarded or arrested

embryonic development. The few species of lizards that have the capacity to support development of retained embryos are members of clades that include viviparous species. This observation suggests that oviparous members of these clades have preadaptations that support embryonic development when egg retention is prolonged. In the present study, we tested the hypothesis that the amount of embryonic development normally attained *in utero* is related to *in utero* oxygen partial pressure (pO_2). The three species of phrynosomatid lizards we used are characterized by developmental arrest (*Urosaurus ornatus*), retarded development (*Sceloporus virgatus*), and normal development (*Sceloporus scalaris*) when eggs are retained. We incubated eggs of these species for 10 d under conditions that simulated retention in the oviduct at a range of experimental oxygen partial pressures. A second group of individuals were induced to retain their eggs for the same period of time. We estimated *in utero* pO_2 from a standard curve generated from the stage and dry mass of experimental embryos incubated for 10 d at known pO_2 . The standard curve was then used to predict the pO_2 associated with the observed *in utero* rate of embryonic development. The results of this study showed that the maximum degree of embryonic development attained *in utero* during egg retention was positively associated with *in utero* pO_2 . The results indicate that oxygen availability *in utero* is associated with interspecific differences in the capacity to support intrauterine development in sceloporine lizards.

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Realized thermal niche of Gulf of Mexico sturgeon in the Suwannee River, Florida

The most southerly distributed form of sturgeon in North America, Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*), experience a wide range of seasonal temperatures. A total of 30 adult Gulf sturgeon were tagged with archival temperature loggers, as they entered the Suwannee River, Florida. Three fish were subsequently recovered. Based on hourly temperature data collected over a 1.5 year sampling period, seasonal temperatures recorded by the tags varied from 8 to 28.5 Celsius. Extremes in water temperature measured in the Gulf of Mexico and the Suwannee River exceeded that observed from archival tag data suggesting behavioral temperature preference. Comparisons of manual temperature measurements near 18 sonic tagged sturgeon compare favorably with data observations collected from archival tags. As a controlling factor in metabolism, detailed thermal data from Gulf sturgeon will provide a more clear picture of Gulf sturgeon bioenergetics.

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Behavior of a bizarre salamander, the Lesser Siren (*Siren intermedia*)

Virtually nothing is known of the reproductive and feeding behavior of the

salamander family Sirenidae. In particular, we hope to determine the mode of fertilization utilized in the salamander species, the Lesser Siren (*Siren intermedia*). Previous studies have failed to determine this, with evidence supporting both internal and external fertilization. Clutches of eggs have also been described as being laid singly or in small clusters, to being laid in a mass of hundreds, with an attending female. These contradictory observations have led us to begin a research project to solve a great mystery in amphibian biology. Bite marks and vocalizations also suggest interesting social behaviors. We have documented rotational feeding, similar to crocodilians. Usually this is initiated when a feeding salamander is approached by another individual. Both males and females bite each other. We have constructed some aquaria in an *ant farm* set up so that we can observe their behavior under the substrate and other aquaria have vegetation and clear plastic tubing to simulate burrows. These aquaria are under low-light video surveillance to capture their nocturnal behaviors. The combination of nocturnal video recording and unique artificial habitats allow us to document the social behaviors of this enigmatic salamander species.

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Hybrid response to pathogen infection in interspecific crosses between two amphibian species (Anura: Ranidae)

Interspecific hybridization can affect fitness related traits, such as response to pathogens. Few experimental studies have directly addressed the effects of pathogens on host fitness in hybrid zones, particularly in animal systems. I used a system of hybridizing leopard frogs to test for differences in response to disease as a function of genetic admixture. I raised F1 hybrid and parental genotypes between *Rana blairi* (plains leopard frog) and *Rana sphenocephala* (southern leopard frog) in replicated experimental tanks, and tested the effect of an emergent amphibian fungal pathogen (*Batrachochytrium dendrobatidis*), on larval growth and development. *B. dendrobatidis* did not significantly affect larval survival for any genotype, but it reduced body mass at metamorphosis and increased duration of the larval period for all genotypes. F1 hybrids experienced smaller metamorphic body masses and longer larval periods than both parental genotypes, but only in pathogen environments. Significantly more F1 hybrids were infected than either parental species. These data indicate that interspecific hybridization may produce relatively fit hybrid genotypes in pathogen free conditions, but hybrids suffer decreased performance in the presence of *B. dendrobatidis*. Such results suggest that hybridization between divergent amphibian lineages may produce hybrid genotypes with reduced capabilities to cope with emergent pathogens.

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Exposure of nursery-bound lemon sharks, *Negaprion brevirostris*, to dietary non-essential trace metals at Bimini, Bahamas

Dredging and removal of mangroves may result in increased availability of non-essential trace metals (NTMs) to marine food webs. NTMs are not required by sharks and may be toxic at high levels, resulting in reduced growth. Mangrove removal and sediment dredging at North Bimini, Bahamas (25°44'N 79°16'W) since 1999 coincided with reduced growth rates in nursery-bound lemon sharks (*Negaprion brevirostris*). Subsequently, we investigated arsenic, mercury, nickel, lead and uranium concentrations in sediments ($n = 29$) and major prey of juvenile lemon sharks ($n = 153$, 8 families) from the impacted nursery and an unimpacted control nursery at Bimini. All NTM concentrations were higher in sediments from the impacted nursery, with significantly greater levels of arsenic and mercury (Kolmogorov-Smirnov tests, $P \leq 0.01$). Concentrations of NTMs in lemon shark prey were similar in both nurseries. Mojarra (*Gerreidae*) dominate the diet of juvenile lemon sharks at Bimini, and consistently contained some of the highest levels of NTMs. All NTM concentrations increased slightly with mojarra total length, although none were significant. Dietary composition and daily ration estimates were used to predict NTM dietary exposure in lemon sharks. Shark consumption rates and prey size increase with shark length and therefore dietary exposure to NTMs further increases as sharks grow. Dietary exposure to NTMs may contribute to the reduced growth rate observed in juvenile lemon sharks at North Bimini, although further studies are required. The potential release of sequestered metals from North Bimini sediments may result in trophic bioaccumulation of NTMs within this essential fish habitat over the next several years. These baseline sediment and prey metal data can be used to monitor impacts of continued habitat degradation at Bimini on the life history of lemon sharks.

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Fish habitat in an anthropogenic landscape: Characterizing the stationary habitat mosaic along an estuarine gradient

We evaluated the mosaic of habitat conditions available to fish across a gradient of shoreline development within the Pascagoula River estuary, MS to determine whether habitat characteristics were influenced by the degree of surrounding alteration. Three treatments were defined: 1) severe alteration at the river's mouth; 2) an intermediate level of alteration and 3) natural conditions 5 km upstream. Six water-quality variables, sediment organic content, grain-size distribution, and prey availability measures such as infaunal richness/diversity and epifaunal richness/diversity were quantified as indicators of habitat quality.

Measurements for each were taken adjacent to both 'restricted' or hardened shoreline and 'unrestricted' or marsh-edge shoreline within each treatment. All abiotic data were analyzed using PCA and the resulting factors used to graphically represent habitat variability along this gradient. Epifaunal richness showed a significant interaction between treatment and shore type (two-way ANOVA, $p = 0.006$) though richness was consistently significantly lower ($p = 0.002$) at restricted shore types in all three treatments. However, infaunal richness did not vary significantly among treatments or shore types. Cluster analysis and non-metric MDS performed using PRIMER showed epifaunal and infaunal communities from unrestricted shore types in treatments 2 and 3 were more similar to each other than any other sample. SIMPER analysis of the data indicated infaunal composition was not dissimilar among treatments or shore types. In contrast, the presence and abundance of two major fish prey items, *Corophium louisianum* and *Hargeria rapax*, in the epifaunal samples were the greatest contributors to treatment and shore type dissimilarity. Treatment 1 was more dissimilar to treatments 2 (87.86%) and 3 (90.91%) than they were to each other (79.07%) and restricted shore types were dissimilar to unrestricted shore types (88.45%). Our data suggest the relative quality of marsh-edge habitat for estuarine fish may depend upon the characteristics of the surrounding landscape.

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Multi-scale habitat characteristics of pond-breeding amphibians across a rural-urban gradient

Biologists are increasingly concerned with the impact of urban sprawl on species biodiversity. Pond-breeding amphibian populations are particularly vulnerable in anthropogenic landscapes because of their complex life histories. We conducted our study in exurban in western Rhode Island, which ranks among the most urbanized landscapes in North America. In contrast to past studies that used estimates of amphibian occurrence at breeding ponds to assess effects of landscape composition, we used egg mass counts of two species (wood frogs [*Rana sylvatica*] and spotted salamanders [*Ambystoma maculatum*]) as an index of annual breeding effort. During 2000 and 2001, we investigated relationships between habitat composition at multiple spatial scales (within ponds, 0-30 m from ponds, 0-100 m, 0-200 m, 0-500 m, 0-1000 m, and landscape patch) and amphibian annual breeding effort at 124 ponds. Based on an information-theoretic approach, the best models suggested that populations of both species were affected by a combination of within-pond habitats and landscape-level habitat characteristics. Wood frog populations were positively influenced by the availability of suitable breeding ponds, and the availability of forested wetlands and forest uplands within 1 km of breeding ponds, while spotted salamander populations were positively influenced by within-pond habitat structure and the availability of forested uplands near breeding ponds, and negatively influenced developed lands near breeding ponds. Our results found that only areas in western Rhode Island that have low road densities are likely to have large wood frog and spotted salamander populations. Effective conservation of amphibian

species, including wood frogs and spotted salamanders that are currently considered widespread and ubiquitous, must begin before environmental thresholds are exceeded and populations decline to unsustainable levels.

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Determining the mechanisms of juvenile amphibian orientation on leaving natal ponds

Research has shown that some amphibians are able to orient towards habitat features. It is not always clear whether these animals have the ability to directly detect the cue towards which they are moving, e.g. scenting water from a wetland, or are detecting an indirect cue, e.g. the angle of the sun, that is consistently correlated with the location of suitable habitat. In 2004 we documented orientation of juvenile wood frogs, *Rana sylvatica*, translocated from an isolated population in Maine where metamorphs orient northeast towards a forested wetland. Study animals were placed in artificial arrays consisting of a central artificial pool, with a circular drift-fence at 0.2 m from the pool's edge to assess orientation of metamorphs at emergence, and a fence at 5 m to assess orientation post-emergence. Arrays were placed with a forested wetland cue to the southwest, i.e., opposite to the site from which the animals were translocated. *Rana sylvatica* showed significant orientation towards the northeast at the 0.2 m fence, i.e. emerging metamorphs retained the same directionality as at the site from which they were collected. A marginally significant result at the outer fence indicated that animals continued to head towards the northeast, although some turned in the direction of the forested wetland cue. These results suggest that isolated populations of *Rana sylvatica* may rely on indirect cues for orientation. The means by which amphibians orient can determine the effects of landscape change. If cues originating directly from the target location are used, animals are more likely to be able to behaviorally adapt to changes in habitat features. Relying on indirect cues offers less adaptability to changes in habitat such as breeding site loss or road construction, and could act as an ecological trap.

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Directional sexual selection on chroma and within-pattern color contrast in *Labeotropheus fuelleborni*

Speciation via intersexual selection on male nuptial colour pattern is thought to have been a major force in promoting the explosive speciation of African haplochromine cichlids, yet there is very little direct empirical evidence of directional preferences within populations. In this study, we used objective spectrophotometry and analyses based on visual physiology to determine whether females of the Katale population of *Labeotropheus fuelleborni*, a Lake

Malawi haplochromine, prefer males that have higher chroma and more within-pattern colour contrast. In paired male preference tests, female *Katale L. fuelleborni* showed increasing preferences for males with more relatively saturated colours on their flanks. They also showed increasing preferences for males with relatively higher contrast levels among flank elements. This is the first empirical evidence, to our knowledge, for male colour as a directionally sexually selected trait within a haplochromine cichlid population.

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The vocal sac increases call rate in the túngara frog, *Physalaemus pustulosus*

In most anurans, the production of advertisement calls is accompanied by the inflation of a vocal sac. This correlation suggests that the vocal sac is important for call production. The function of the vocal sac, however, is not fully understood although several non-mutually exclusive hypotheses have been proposed. Acoustic hypotheses posit that the vocal sac functions as a sound resonator, sound radiator, and to impact call directionality. Potential non-acoustic functions include that the vocal sac is a visual cue, reduces the energetic costs of calling, or increases the time available for calling by preventing repeated bouts of buccal pumping. We examine this final hypothesis by analyzing audio and video recordings of calling túngara frogs, *Physalaemus pustulosus*. To call, an uninflated male frog uses buccal pumping to inflate his lungs. Once inflated, little to no buccal pumping occurs between calls. We compare the first two call bouts emitted by an originally uninflated male. The first call bout requires lung inflation via buccal pumping, but in the second, the male is already inflated due to capture of air and re-inflation of the lungs by the vocal sac. Our results indicate that complete inflation of the lungs requires 26 to 51 buccal pumps, which requires four to nine seconds. Therefore, minimum intercall intervals using buccal pumping are more than 2.5 times greater than the minimum intercall intervals possible with lung re-inflation using a vocal sac. We test these differences in intercall intervals (i.e. call rate) using phonotaxis tests. Female *P. pustulosus* prefer the shorter intercall interval/higher call rate. Our results demonstrate that the vocal sac increases the call rates that can be attained by males and does so by an amount that is salient to females.

PAVANELLI, CARLA S.

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New *Apareiodon* species from the Rio Tibagi, upper Rio Paraná basin, Brazil

Parodontidae contains three genera: *Parodon* Valenciennes, 1850, *Saccodon* Kner, 1863, and *Apareiodon* Eigenmann, 1916. The last is differentiated from *Parodon* by

the lack of mandibular teeth, and from *Saccodon* by having one unbranched pectoral-fin ray, instead of two. *Apareiodon* species are distributed throughout cis-Andean South America, except in coastal Atlantic basins south of Bahia State (Brazil), Patagonia, and the Rio Amazonas channel. Currently there are fourteen valid *Apareiodon* species. Prior to this study, four *Apareiodon* species, *A. affinis* (Steindachner, 1879), with type locality La Plata, Argentina, *A. ibitiensis* Campos, 1944, type locality Rio Camanducaia, São Paulo State, Brazil, *A. piracicabae* (Eigenmann, 1907), type locality Rio Piracicaba, São Paulo State, Brazil, and *A. vladii* Pavanelli, 2005, type locality Rio Piquiri, Paraná State, Brazil had been recognized as occurring in the upper Rio Paraná basin. The first occurs in the Rio de La Plata basin, the last is apparently restricted to the Rio Piquiri drainages, and the other two, besides the type locality, also occur in the upper Rio São Francisco basin. During recent samples a new *Apareiodon* species was revealed at Rio Tibagi headwaters, tributary to upper Rio Paraná. The new species is distinguished from most *Apareiodon* species by having dark vertical bands and/or blotches below the lateral line region; however, it shares the coloration pattern with *A. ibitiensis*, and *A. tigrinus* Pavanelli & Britski, 2003, from the Rio Tocantins-Araguaia system. From the former it can be distinguished by having a longer caudal peduncle, its length 5.5 to 6.8 times in standard length, 1.1 to 1.4 in body depth, and 1.1 to 1.4 in dorsal-fin length (*A. ibitiensis* has respectively caudal-peduncle length 7.4 to 10.5, 1.5 to 2.5 and 1.5 to 2.5). From the latter it can be differentiated by presenting one maxillary tooth (*A. tigrinus* has two).

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Competition and the evolution of heterospecific aggressive behaviour in brook stickleback

When two species compete for a common resource, evolution should favour traits that assist in the acquisition or monopolization of that resource. Recent reviews support the role of resource competition in morphological character shifts, termed ecological character displacement (ECD), but little attention has focused on the evolution of behavioural characters. Alpha-selection is the evolution of heterospecific interference traits, such as aggressive behaviour, when resources are defensible. Interference traits allow species to directly interact in a way that is not mediated by their effects on a shared resource. Standard ECD does not readily account for the evolution of interference traits because ECD results from exploitative (indirect) competitive interactions mediated through a shared resource. Prior studies suggest that ECD has occurred in brook stickleback (*Culaea inconstans*) sympatric with ninespine stickleback (*Pungitius pungitius*) among a series of post-glacial lakes in northern Ontario, Canada. Here we investigate whether aggressive behaviour has also evolved in this system. We predicted that if heterospecific aggressive behaviour increases fitness by allowing individuals to monopolise defensible benthic resources, then *C. inconstans* sympatric with *P. pungitius* should have a higher level of aggression than solitary (allopatric) populations of *C. inconstans*. We reared family groups from replicate populations of allopatric and sympatric *C. inconstans* in a common laboratory environment to test for consistent variation in aggressive behaviour toward a heterospecific intruder, and to test for heritable variation in aggressive behaviour. Aggression in juvenile *C. inconstans* increased

with age in sympatric but not in allopatric populations. That aggressive behaviour is heightened over ontogeny and not just at sexual maturity suggests that it functions outside of a mating context. This is one of the first studies to provide evidence that aggressive behaviour has likely evolved under selection imposed by heterospecific competitors.

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Synclinal variance in morphology within the *Fundulus notatus* complex

Variation in morphology among fish species is known to correspond with varying geomorphology. We examined range-wide collections of the *Fundulus notatus* complex to determine if they exhibit such variation in morphology. This clade includes *Fundulus notatus* which ranges from the coastal plain to the Illinois Basin, and *Fundulus olivaceus*, which occurs in drainages south of the Illinois Basin. Both species extend west of the Mississippi but are bounded to the east by the Appalachian uplift. Also included is *Fundulus euryzonus* an endemic to the Lake Pontchartrain drainage. Both *Fundulus notatus* and *Fundulus olivaceus* are known to be genetically divergent; therefore, we hypothesized that sympatric species would show similarities in morphology, while distinct populations either within or between drainages (synclines) would exhibit morphological variation. In contact zones, however, *Fundulus notatus* and *Fundulus olivaceus* are known to hybridize. Hybridization between the species is not well understood, and we hypothesized that morphological variability may be a distinguishing feature. Landmark-based geometric morphometrics were applied to assess the degree of morphological variation within the complex. This method was used to produce a set of Cartesian coordinates for each landmark. A Procrustes transformation was then performed on all fishes to determine the consensus point for each landmark. Residual vectors were analyzed with MANOVA to determine if significant differences in shape existed. The thin-plate spline method was then used to transform all vector residuals into shape variables. Principal component analysis (PCA) was used to visualize the shape variables produced from the thin-plate spline analysis of the landmark data.

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Buoyancy regulation in two species of freshwater turtles

Aquatic turtles must surface periodically to breathe air. Costs of surfacing, diving, and underwater life in general are likely to be strongly influenced by an animal's buoyancy, which can be measured as specific gravity (SG). The large, dense shells of turtles are negatively buoyant, and the tendency to sink is opposed by air in the lungs. Turtles can therefore regulate buoyancy by adjusting residual lung volume, but must do so within the constraint of a fixed body volume set by the rigid shell. Among freshwater turtles, buoyancy regulation has been previously studied only in the emydid *Trachemys scripta*, which were

reported to compensate for changes in lung volume with changes in the volume of water stored in the urinary bladder and, for rapid short-term adjustments, the cloacal bursae. We examined buoyancy control in two local species, the eastern painted turtle *Chrysemys picta* (Emydidae), which has well-developed cloacal bursae, and the common musk turtle *Sternotherus odoratus* (Kinosternidae), which lacks bursae. We placed size-matched pairs of turtles in 30 cm of water for at least 24 hr, then measured SG by weighing them both underwater and in air. We then manipulated SG by attaching either weights or floats and measured SG again at 4 h and 24 h after attachment. Initial SG was consistently higher in *Sternotherus* (1.03) than in *Chrysemys* (1.01). Both species compensated completely for floats by increasing mass in water (reflecting lower lung volumes) and in air (higher stored water volume); compensation at 4 h was incomplete for both species but slightly more rapid in *Chrysemys*. Painted turtles also compensated completely for weights, but *Sternotherus* did not, apparently due to limitations in attainable lung volumes. Differences in buoyancy compensation between species reflect differences in natural history and morphology.

PETERSON, JOHN D.

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Growth effects of heavy metals and chytridiomycosis exposure during development and metamorphosis in *Rana sphenoccephala*

Anthropogenic contaminants and infectious diseases are two of the stressors suggested to account for recent global amphibian population declines. Given that larval development and metamorphosis are extremely sensitive events in amphibian life, exposure to contaminants and disease during these times can have drastic effects on adult fitness and survival. In spring 2005, we exposed southern leopard frog tadpoles, *Rana sphenoccephala*, to coal combustion residues (CCRs), a major global pollutant byproduct of coal burning power plants, and chytridiomycosis (chytrid), a fungal disease that has caused numerous amphibian population declines world-wide. Tadpoles were randomly allocated to one of three treatment groups (48 individuals/treatment): control, chytrid, and CCR. Each individual was housed in its own plastic tub with water and either CCR substrate or clean sand (control and chytrid treatments). Growth and developmental rate was determined as mass, length, and time to four developmental stages; initial hind limb growth (30 days post hatch), complete hind limb development (Gosner stage 39), forelimb emergence (Gosner stage 42), and complete tail resorption (Gosner stage 46). Changes in larval growth, developmental rate, malformations, mortality, and metamorphic success should provide insight into the impact these environmentally relevant stressors have on key bottleneck events in anuran life history. This study is important because it addresses how contaminants and diseases may potentially contribute to amphibian population declines. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

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Chytridiomycosis prevalence in *Rana catesbeiana* and *R. sphenoccephala* at the Savannah River Site, South Carolina

Although numerous amphibian populations, world-wide, have been drastically affected by the fungal disease, chytridiomycosis, authors have suggested that some populations may support the presence of this disease without noticeable long-term effects. For the past 25 years, amphibian populations native to the Savannah River Site (SRS), South Carolina have not experienced any drastic decline events though chytridiomycosis was documented in three adult individuals (two American bullfrogs, *Rana catesbeiana* and one southern leopard frog, *R. sphenoccephala*) collected there in the late 1970s and early 1980s. Given that so little is known about chytridiomycosis presence within populations at the SRS, we conducted a field survey to identify whether chytridiomycosis is still present within these intensively studied populations and if this disease is more prevalent in amphibians exposed to greater amounts of heavy metal pollution. More extensive information on the prevalence of chytridiomycosis within these populations could provide insight into variables (e.g. pollution, temperature, stress, etc.) that may affect the virulence of this disease. In the summer of 2004, larval American bullfrogs (*R. catesbeiana*) and Southern leopard frogs (*R. sphenoccephala*) were collected from three different wetlands on the SRS; the first was contaminated with elevated levels of numerous heavy metals from coal incineration (N=100 *R. catesbeiana*), the second was contaminated with elevated levels of copper and mercury (N=100 *R. catesbeiana*, 100 *R. sphenoccephala*), and the third was uncontaminated (N=100 *R. catesbeiana*, 53 *R. sphenoccephala*). Upon collection, tadpoles were euthanized, histologically sectioned and stained. Additionally, tadpole, soil, and water samples were collected to determine heavy metal concentrations. Preliminary examination of a subset of samples indicates that chytridiomycosis is still present within amphibians on the SRS; its extent and prevalence will be discussed.

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Foraging in non-native environments: comparison of Nile tilapia and three co-occurring native centrarchids in invaded coastal Mississippi watersheds

We examined the diets of the established alien Nile Tilapia, *Oreochromis niloticus*

(n=590) and bluegill, *Lepomis macrochirus* (n=129), redear sunfish, *L. microlophus* (n=73) and largemouth bass, *Micropterus salmoides* (n=100) over a two year period in invaded coastal Mississippi environments. The diet of Nile Tilapia was visually separated by species and season from the three native species using the UPGMA cluster analysis and the non-metric MDS of PRIMER based on frequency of occurrence data. A two-way nested ANOSIM analysis (season nested under species) indicated differences were significant only for species (global $r = 0.74$, $p = 0.1\%$). Pairwise tests indicated all species fed on different components of and locations within the environment, with bluegill and redear sunfish having the most similar dietary components. SIMPER analysis indicated that diets were separated based on different prey complements: bluegill and redear sunfish consumed chironomids and insects; largemouth bass consumed fish and less often insects; and Nile tilapia fed most often on prey found in the sediments like nematodes, rotifers, bryozoans and hydrozoans. All species often had detritus and amorphous debris in their stomach but Nile tilapia had considerable volumes of mud and sand, suggesting they fed directly on bottom sediments (and constituents). These data and the fact that Nile tilapia have no stomach and an intestine 1.3-7.6 times on average longer than the fish, support our contention that this species feed at the base of the food web and are extremely adapted to survive and proliferate in non-native environments.

***PIERCY, ANDREW; FORD, TRAVIS; KELLER, THOMAS; LEVY, LAURA; HENNESSY, KELLY; SNELSON, FRANKLIN**

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Analysis of variability in vertebral morphology and growth ring counts in two Carcharhinid sharks

This study examined the variability in morphology and growth ring counts of vertebral centra taken from two regions of the vertebral column from two shark species, *Carcharhinus plumbeus* and *C. limbatus*. Sets of five adjacent vertebrae were removed from the vertebral column above the branchial region and below the first dorsal fin. Medial lateral breadth, caudal-cranial length, and dorso-ventral heights were measured for each vertebra. Additionally, a subset of vertebrae was sectioned and growth rings were counted. Intra- and inter-regional differences in morphology and growth ring counts were determined using multiple regression analysis.

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Morphological changes in the clasper gland of the Atlantic Stingray, *Dasyatis sabina*, associated with the seasonal reproductive cycle

The clasper gland of the Atlantic stingray, *Dasyatis sabina*, was examined over a

one-year period, covering an entire reproductive cycle. Changes in clasper gland tissue architecture, fluid production, and cell proliferation were assessed. No changes in tissue architecture were observed. Evidence of cell proliferation in the gland epithelium was not detected using immunocytochemistry for Proliferating Cell Nuclear Antigen, a cellular marker of mitosis. Epithelial cells were not observed to undergo mitosis, and cell membranes remained intact. The lack of structural changes and epithelial cell proliferation supports the proposed merocrine mode of fluid secretion. Rays captured in non-breeding months had clasper glands that exhibited tubules with reduced lumens. In contrast, rays caught during the breeding season had clasper gland tubules with enlarged lumens. Clasper gland fluid production was quantified through measurements of the fluid area and tubule area calculated from digital images. Clasper gland fluid production was significantly higher during the mating period than during months not associated with copulatory activity. These data support the notion that the clasper gland is involved in stingray copulatory activity. This study adds to the paucity of literature focused on this poorly understood component of reproduction in skates and rays. **AES CARRIER**

***PIKE, DAVID A.; ANTWORTH, REBECCA L.; STINER, JOHN C.**

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Global warming causes earlier nesting in sea turtles: effects on nesting season duration

Evidence is mounting that warming air and sea temperatures are affecting nesting patterns in oviparous species, specifically by causing earlier nesting within seasons. The potential fitness consequences of nesting earlier include less competition for quality nest sites, extended periods of offspring growth, and larger clutch sizes. Additionally, the potential for nesting seasons to last longer exists, possibly allowing species that lay multiple clutches within a season to increase the number of clutches produced. To date no studies have examined the consequences of earlier nesting on the duration of the nesting season. We demonstrate that warmer sea surface temperatures are related to earlier nesting in the loggerhead sea turtle *Caretta caretta*, and that this response actually decreases, rather than increases, the length of the nesting season. In more recent years (1995-2003) the entire nesting season advanced and became more evenly distributed throughout the nesting season than in earlier years (1989-1994). Nesting is therefore occurring over a shorter time period and at earlier dates during seasons with warmer sea surface temperatures. Female turtles are unlikely to produce additional clutches within a reproductive season in response to this effect because of physiological constraints, and do not appear to gain any direct fitness advantage from warmer temperatures via the production of additional clutches.

PILGRIM, MELISSA A.

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Microgeographic variation in isotopic composition of rattlesnake prey:
Implications for using isotopes as dietary indicators.

Variation in stable isotope ratios has been used to quantify trophic relationships in many communities. My long term research goal is to test the validity of the stable isotope approach for determining differences in pigmy rattlesnake (*Sistrurus miliarius*) diet composition among three Florida populations located less than 4km apart. To use stable isotopes as dietary indicators, prey species must have distinct isotope profiles. In order to evaluate isotopic variation in the rattlesnake prey base, I used drift fence arrays to collect a representative sample of prey items from each population. I collected 992 prey items, representing 10 amphibian, 8 reptile and 7 mammal species. For each species, I combined captures from all three populations and generated site-wide average ^{13}C and ^{15}N values. Site-wide averages were variable (^{13}C values ranged from -31.1 to -14.5 and ^{15}N values ranged from 0.3 to 7.0) and showed considerable overlap. Taxonomy was not the best predictor of isotopic similarity among prey species. *Hyla squirrellla* (Squirrel treefrogs) had the most depleted ^{13}C values, while its congener *Hyla cinerea* (Green treefrogs) had among the most enriched ^{13}C values. Conversely, congeners *Anolis carolinensis* and *Anolis sagrei* showed two of the most similar isotopic compositions. Generating site-wide averages was not the appropriate scale for my investigation; however, it illustrated pitfalls associated with the traditional isotope approach to studying diet. For example, there was no a priori reason to expect prey species that occurred in all three populations to look isotopically similar. *Rana utricularia* (leopard frogs) were a major prey item available in each population. Leopard frog ^{13}C values showed significant variation among populations. In addition, ontogenetic shifts in leopard frog isotopic composition varied by isotope and population. Assessment of rattlesnake diets using stable isotopes requires generating population-specific and size-specific prey profile plots that incorporate ontogenetic shifts in isotope ratios.

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The relationship between pigmy rattlesnake (*Sistrurus miliarius*) maternal and offspring scale tissue isotopic composition.

Long-term goals of my research involve using stable isotopes to investigate population level diet variation of pigmy rattlesnakes (*Sistrurus miliarius*). I have established that isotopic composition of pigmy rattlesnake scale tissue reflects diet isotopic composition. However, scale tissue had a relatively long turnover rate, so initial isotopic composition of neonates could impact the isotopic composition of juvenile animals in field populations for several months. Thus, for meaningful interpretation of field collected data, it is important to quantify starting isotopic composition of neonate scale tissue. I captured 21 gravid rattlesnakes from my focal populations. I housed gravid rattlesnakes in field enclosures until parturition. Between 7/29/02 and 8/31/02, gravid rattlesnakes produced 124 living offspring. Maternal ^{13}C values ranged from -18.4 to -23.4,

while maternal ^{15}N values ranged from 5.9 to 9.0. Neonate ^{13}C values ranged from -17.5 to -25.0, while neonate ^{15}N values ranged from 7.1 to 9.9. There were significant population level differences in maternal ^{13}C values and these differences were reflected in ^{13}C values of neonates. Over 95% of the variation in offspring carbon and nitrogen isotopic composition was expressed among litters. ^{13}C shifts between maternal isotopic composition and average litter isotopic composition ranged from 0.3‰ to -2.5‰. On average, litter ^{13}C values were 1.2‰ depleted relative to maternal ^{13}C values. ^{15}N shifts between maternal isotopic composition and average litter isotopic composition ranged from -0.2‰ to 2.7‰. On average, litter ^{15}N values were 1.1‰ enriched relative to maternal ^{15}N values. Focusing on average changes between maternal and offspring isotopic composition masks an interesting finding. Individual shifts observed between females and their offspring were of very different magnitudes for both carbon and nitrogen isotopes. Understanding why maternal-offspring isotopic differences are so variable may illuminate changes in physiological state during pregnancy and the degree to which maternal resources may shift temporally.

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Understanding the population structure of the turtle *Mauremys rivulata* (Testudines: Bataguridae) on the Island of Crete

This project is concerned with the health and conservation status of the turtle *Mauremys rivulata*, the only endemic freshwater turtle on the Island of Crete. The turtle is common in its natural semi-aquatic habitats, and natural wetlands are gravely endangered on Crete suggesting that the loss of native habitat over time has eliminated some populations throughout the island. Our study addresses whether the species on the island is experiencing genetic problems such as loss of genetic diversity, inbreeding depression, and genetic fragmentation. This ongoing study surveys the existing genetic diversity and serves as an example of how artificial wetlands on islands can impact the genetic diversity and conservation of semi-aquatic vertebrates.

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Ecomorphology of boine snakes, with emphasis on South American forms

Boine snakes occur in some Pacific Islands, Madagascar, the Caribbean, and in South America. We explored relationships between body size and shape (circumference around midbody, head length, lateral compression, number of

subcaudals and ventrals scales, and sexual size dimorphism - SSD) and macrohabitat use in South American boine snakes. Analysis of body size, number of subcaudals, and macrohabitat also included *Candoia* spp., Madagascarian boas and Caribbean rainbow boas. More arboreal snakes (*Corallus caninus* and *C. hortulanus*) are more laterally compressed, whereas aquatic forms (*Eunectes* spp.) are less compressed. Number of ventrals is highly conservative among boines. Aquatic and arboreal species have more subcaudals (i. e., an elongated tail). Body circumference (stoutness) is smaller in arboreal forms, especially in *Corallus hortulanus*. Body length and SSD seem to be conservative and not closely associated with macrohabitat use. Species that are specialized in feeding on mammals (*C. caninus* and *C. cropanii*) have longer heads, while generalists like *C. hortulanus* and *E. murinus* have shorter heads. Evolution of these characteres was inferred by character optimizations on two phylogenetic hypotheses: one based on morphology and another based on molecular data. Both optimizations indicate that the ancestor of boines was a stout, short-tailed, non-laterally compressed snake, with a moderate head length. The character optimization on a tree based on morphology indicates that the ancestor of boines was a semi-arboreal, medium-sized snake (0.72-1.1 m in SVL) with a marked SSD (females larger than males). In contrast, the optimization on a tree based on molecular data indicates that the ancestor of boines was a large (about 1.4 m) semi-arboreal or terrestrial, non-sexually dimorphic snake.

PLACYK, JOHN S., JR.

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Variation in life history traits and population demographics of Michigan gartersnake (*Thamnophis sirtalis*) populations

The common gartersnake (*Thamnophis sirtalis*) is the most widespread snake in North America, occurring in nearly every natural habitat found throughout its range. While the reproductive characteristics of *T. sirtalis* populations are known to vary considerably across its vast range, little data on such characteristics from populations that occur relatively close to each other is available. This research utilizes island and mainland populations of Michigan gartersnakes that are located relatively close to each other, but that differ in various characteristics (e.g., density, predator composition, prey availability). In addition to variable habitat characteristics that may drive variation in reproductive characteristics, these populations were also utilized, because their underlying genetics were recently revealed. As a result, patterns of variation resulting from historical processes could be detected and disseminated from patterns resulting from current environmental conditions. Despite the underlying genetics of the populations sampled and the proximity of the populations to each other, reproductive characteristics such as litter size and neonate mass varied considerably between populations corresponding strongly with current environmental characteristics. The data from this work indicate that environmental factors, especially, play a substantial role in the reproductive characteristics exhibited by gartersnake populations, but that the influence of the underlying genetics of a population may also be important and should be taken into consideration.

***PLACYK, JOHN S., JR.; BURGHARDT, GORDON M.; CASPER, GARY S.; SMALL, RANDALL L.; KING, RICHARD B.; ROBINSON, JACE W.**

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Post-glacial recolonization pathways into the Great Lakes region by the Common Gartersnake (*Thamnophis sirtalis*) inferred from mtDNA sequences

Pleistocene events played an important role in the differentiation of vertebrate populations in the Great Lakes region. While several hypotheses regarding recolonization of this region have been advanced, none have been strongly supported. We generated 148 ND2 mitochondrial DNA sequences from common gartersnake (*Thamnophis sirtalis*) populations throughout the region to evaluate phylogeographic patterns and population structure and to determine whether the distribution of haplotypic variants is related to the retreat of the Wisconsinan glacier. The common gartersnake was utilized, because it was one of the primary vertebrate invaders of the region following the most recent period of glacial retreat and because it has been a model species for a variety of evolutionary, ecological, and behavioral studies over the last 50 years. Several genetically distinct evolutionary lineages were supported by both genealogical and molecular population genetic analyses. The geographic distribution of these lineages is interpreted as reflecting post-glacial recolonization dynamics during the late Pleistocene. Specifically, an older cluster of haplotypes is found primarily in the states below Lake Michigan (Illinois, Indiana, Ohio) with two more derived clusters extending from Indiana northward into the lower peninsula of Michigan and from Ohio, Indiana, and Illinois northward into Wisconsin and the upper peninsula of Michigan. These findings generally support previous hypotheses of range expansion in this region. The two more derived clusters of haplotypes also come into secondary contact in the Beaver Archipelago of northeastern Lake Michigan, which leads us to reject earlier hypotheses that this archipelago was colonized from lower peninsula populations only.

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Trachinocephalus myops (Pisces: Synodontidae): One or several species in the world?

The bony fish family Synodontidae (order Aulopiformes), has been divided in two subfamilies, each one with two genera, including a total of about 54 species. The genus *Trachinocephalus* Gill, 1862 is considered monotypic since 1966, following W. W. Anderson and collaborators review of the family for the western

North Atlantic. They presented the distribution of the only accepted species, *T. myops* (Forster, 1801), as almost circumtropical, going from the western tropical and subtropical Atlantic to the Central Pacific, and being absent from the Eastern Pacific. The species is reported to occupy a wide depth range, going from very shallow waters to 400 m. However, the papers reporting the species from different world localities do not agree in all the meristic and morphometric information presented. With the aim of testing the possibility that several sibiline species may be confused under the name *myops*, 117 specimens coming from 10 different localities distributed in the three tropical oceans were examined. Each specimen was measured (21 measurements) and counted (five countings). Consistent statistical differences lead to separate the species in three populations: one in the Atlantic Ocean, another in the Indian and Western and Central Pacific, and another one in the Marquesas Islands. If specific status is accepted for each of those populations, the name *myops* will be restricted to the Atlantic Ocean, the name *trachinus* Temminck and Schlegel, 1846 is available for the Indo-Western Pacific populations, and the population restricted to the Marquesas would be a new species.

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The importance of watersheds to fishes in an oligotrophic lake: Food, temperature, predation risk, and near-shore habitat selection

Small headwater streams can be important links that transmit organic material and macroinvertebrates produced further up the watershed to downstream habitats. We observed near-shore habitat use in an oligotrophic lake by resident and anadromous fishes and compared mechanisms of habitat selection at sites that received input from headwater streams and sites that lacked input from watersheds ("control" sites). Juvenile chinook salmon (*Oncorhynchus tshawytscha*) utilize the lake during the late stages of rearing prior to migration and were found to be from 1.5 to 4 times more abundant at stream-input sites than at control sites. Abundance at stream sites was correlated with the size (discharge) of the stream, but dietary analysis of fish indicated that habitat selection was more likely to be driven by thermal refugia created by stream input than by prey resource delivery. The resident sculpin *Cottus asper* was 1.5-2 times more abundant at stream-input sites and showed a stronger link with food resources delivered by the streams suggesting resource-matching as a mechanism of habitat selection which was further confirmed by growth rates measured on marked and recaptured individuals and by isodar analysis that suggested parallel population regulation between microhabitat types. Juvenile sculpins responded to the strong trade-off between foraging opportunities and predation risk from adult sculpins that led to reduced variability in individual condition. These results indicate the importance of watershed health to the early life history of resident and anadromous fishes.

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A hole in the head: Spiracle morphology and importance during exercise

Spiracles are vestigial first gill slits bringing seawater through a narrow passage from the dorsal body wall into the oropharynx. Several proposed hypotheses explain the function of spiracles : 1. Spiracles are presumed to function in ventilation at rest and while feeding. 2. Spiracles may function in O₂ exchange supplying oxygen to the brain and eye. 3. The spiracular organ may be part of the lateral line system and serve as proprioceptors monitoring the position of the hyomandibula. A fourth possibility is that current spiracle distribution is due to phylogenetic relationships. In this study, we examined hypotheses 1 and 4. We looked at the effect of exercise on the rate of buccal and spiracular ventilation in the spiny dogfish, *Squalus acanthias*. We exercised dogfish in a racetrack flume and measured spiracular ventilation and buccal ventilation. Based on previous data, rate of buccal ventilation and spiracle opening were expected to exhibit a 1:1 relationship at rest and increase with swimming velocity. Buccal ventilation rate and spiracle opening both increased with swimming velocity (F_{1,144}=15.755, p<0.001 and F_{1,73}=106.47, p<0.001, respectively) and the ratio of spiracle movement to buccal ventilation rate did not change with speed (p= 0.172). This coupling suggests both spiracular and buccal ventilation are important to animals at rest and while swimming at the moderate speeds. However, spiracular ventilation may be less important in extremely fast swimming. We examined spiracle morphology in 15 families in 7 order of cartilaginous fishes. Spiracles are found in all batoids and many basal sharks, but are very reduced or absent in the larger, fast-swimming sharks (e.g., carcharhinids, lamnids). Phylogeny is a strong predictor of spiracle morphology, and our data suggest sedentary/benthic sharks have ovoid rather than circular spiracles. AES
GRUBER

PORTNOY, DAVID S.

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Detection of polyandry and reproductive periodicity in the sandbar shark, *Carcharhinus plumbeus*

Understanding aspects of life history, such as lifetime fecundity and individual reproductive success, are critical to effective management of exploited species. Sandbar sharks, *Carcharhinus plumbeus*, are a major component of the directed shark fishery in the western North Atlantic. Females are thought to mate with multiple males in large aggregations off Florida before returning to specific nursery grounds every two years for pupping. These traits may make the species particularly susceptible to localized stock depletion and loss of genetic variation. As part of a larger study examining the population condition of *C. plumbeus* in the western North Atlantic and gene flow among populations, I set out to investigate philopatry and polyandry while determining reproductive periodicity in females utilizing the Virginia eastern shore lagoons and lower Chesapeake Bay as nursery grounds. Seven novel polymorphic microsatellite

markers allowed for the resolution of familial relationships among individuals sampled in the summers of 2003 and 2004. Kin groups of three or more individuals across cohorts were taken as evidence of philopatric behavior in female sharks. Periodicity was then inferred by assessing the year of birth for all individuals placed within a given kin group through size at age relationships. Polyandrous mating was confirmed by examining genotypes at each locus across individual litters. Detection of more than four parental alleles at two or more loci within a litter was taken as evidence of multiple sires. Multilocus genotypes of a mother and her progeny were then used to determine the minimum number of fathers per litter. Independent methods of assessing paternal contribution were compared and manual inspection of genotype arrays ensured that no full sibling group contained more than four alleles per locus. Results are discussed in terms of management concerns and evolutionary significance.

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Analysis of the antibiotic properties of the epidermal mucus of the Atlantic stingray, *Dasyatis sabina*, conferred by associated bacterial symbionts

To survive in contaminated environments and in microflora-rich seas, estuaries, and riverine systems, elasmobranch fishes have had to evolve efficient host defense mechanisms. Although the capacity of mucus to act as mechanical protection, hydrodynamic lubrication, an anti-parasitic agent, and in osmotic regulation is well established, its potential as a source of novel antibiotic compounds is virtually unexplored. To investigate the role of epidermal mucus in protection against environmental pathogens, samples of mucus from three individuals from a freshwater population of Atlantic stingray, *Dasyatis sabina*, were obtained and antibiotic properties of mucus-associated bacterial symbionts were examined. This was accomplished through the culture of bacterial symbionts to allow antibiotic producers to effuse their antibiotics. A set of tester strain bacteria were then grown on top of the first cultures, and four zones of inhibition were observed. Growth inhibition was shown to be strongest against methicillin-sensitive *Staphylococcus aureus* ATCC 43300 and *Enterococcus faecalis* ATCC 10471. Sixteen symbionts believed to be unique to freshwater Atlantic stingray were selected for identification. Three of these are believed to produce antibiotics. DNA extractions and PCR amplifications of 16S rRNA genes were successful on bacterial symbionts. Phylogenetic placement of bacterial species by means of GenBank BLAST searches against known 16S rRNA genes is currently on going. Results of preliminary searches show the presence of bacteria belonging to genera *Shewanella*, *Flectobacillus*, and *Staphylococcus*.

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West Indian amphibians and reptiles out of place

Introduced West Indian amphibians and reptiles fall into two major categories, those introduced from outside the region (e.g., *Gekko gecko*) and those introduced to other islands within the archipelago (e.g., *Anolis cristatellus*, *A. porcatius*). In addition, some species native to the region have become established on the American mainland (and elsewhere) and, on occasion, those populations have served as the source of new introductions into the islands (e.g., *Osteopilus septentrionalis*, *Anolis sagrei*). None of these categories are mutually exclusive. Further considerations include whether introductions occurred naturally or by means of human agency, and whether the latter were intentional or inadvertent. A very large proportion of unintentionally established colonies are tied to shipments of tropical plants or building materials (e.g., *O. septentrionalis*, *A. sagrei*). Finally, we have species whose presence in the islands has been attributed to humans by some authorities, but disputed by others -- and both situations may apply to different populations on different islands (e.g., *Geochelone carbonaria*). In general, more alien species of reptiles have become established than amphibians. However, in both cases, the largest number of successful introductions are associated closely with habitats that have been moderately to severely altered by human activities. Only in a few instances have introduced species effectively invaded relatively pristine situations (e.g., *Eleutherodactylus johnstonei*).

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Three decades of urbanization: Estimating the impact of landscape change on stream salamander populations

Recent studies of land cover change in the Piedmont ecoregion of the United States reveal a substantial increase in the amount of urban land cover and a corresponding reduction in forested land. Small streams in the Piedmont support high densities of salamanders and are often the first habitats to be affected by landscape-altering factors such as urbanization. Our objective was to estimate the change in abundance of stream salamanders near Davidson, North Carolina, a Piedmont locale that has experienced rapid changes in land use. We used United States Geological Survey Land Use/Land Cover trend data to quantify land cover changes from 1972 to 2000 within watersheds of small headwater streams. Salamander abundance was calculated using models that allowed predictions of the relative abundances of *Desmognathus fuscus* and *Eurycea cirrigera* based on land cover within each watershed. Our analysis suggests that *E. cirrigera*

populations decreased by 30-50% over the last 3 decades and populations of *D. fuscus* have decreased by 20-35%. Most of our estimated population reductions occurred from 1985 to 2000, which correspond with a significant increase in urban land cover. Our results suggest that accelerating rates of urbanization and other landscape changes near Davidson, NC and throughout the Piedmont have likely resulted in a substantial decrease of stream salamanders. The impacts of such a decline on ecosystem function is unknown.

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Body temperatures of *Coluber constrictor* and *Crotalus horridus* during changes in environmental conditions

Variation in climate has received considerable attention with regard to reptile thermoregulation, however, comparisons in how different species respond to this variation are less common. This study examines the effect of weather condition on body temperature (*T_b*) regulation in an active snake (*Coluber constrictor*) and a sedentary snake (*Crotalus horridus*). Hypothetically, active predators will regulate their *T_b* during changes in weather by seeking out more thermally suitable microhabitats whereas sit-and-wait predators will exhibit more subdued responses. We compared the daily *T_b*s of five *C. constrictor* and five *C. horridus* from the same locality in Middle Tennessee. Snakes were implanted with radio transmitters for relocations and temperature loggers for recording *T_b* every 30 minutes. Rainfall was measured at a nearby weather station and used as our indicator of weather variation. We collected 30-42 days of *T_b*s on each snake. Within species, mean *T_b*s did not differ. Daytime *T_b*s of snakes on non-rainy days were higher and more stable (*C.c.* $31.8 \pm 0.29^\circ\text{C}$, *C.h.* $27.7 \pm 0.49^\circ\text{C}$) than on rainy days (*C.c.* $28.7 \pm 1.32^\circ\text{C}$, *C.h.* $24.7 \pm 1.05^\circ\text{C}$). Less interspecific difference and less variation occurred in nighttime *T_b*s (Non-rainy nights: *C.c.* $20.9 \pm 0.62^\circ\text{C}$, *C.h.* $18.9 \pm 0.55^\circ\text{C}$; Rainy nights: *C.c.* $20.4 \pm 0.58^\circ\text{C}$, *C.h.* $18.5 \pm 0.57^\circ\text{C}$). *Coluber constrictor* exhibited abrupt heat-up phases during the morning with distinct plateau phases in mid-day whereas *T_b*s of *C. horridus* increased more gradually and were more variable during these times. Field observations revealed that during periods of rain, *C. constrictor* retreated to burrows or beneath the substrate, while *C. horridus* exhibited little movement. Our findings support that *C. constrictor* is an actively thermoregulating species while *C. horridus* may have a greater tendency to thermoconform to changes in environmental conditions rather than seek out new locations that could provide higher and more stable *T_b*s.

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Detection of *Batrachochytrium dendrobatidis* infections in *Eleutherodactylus fitzingeri*: Effects of stains and body parts used

Batrachochytrium dendrobatidis is a fungal pathogen that has been implicated with amphibian declines worldwide. Histopathological techniques have been used to diagnose the disease, but their sensitivity has not been determined. It is also

unclear whether the power of detection varies using skin from different body parts. Light or localized infections might produce false negatives. We examined 24 *Eleutherodactylus fitzingeri* infected with chytridiomycosis. This is a common frog species with a broad range and high abundance throughout most of Costa Rica. We sampled 12 different body parts in each animal, and alternated the staining between the routine stain, hematoxylin and eosin (H&E), and the more fungus specific stain periodic acid schiff (PAS). We found more samples infected using PAS than H&E in all body parts. Significant differences between body parts were also found. The pelvic patch and the innermost finger of the hand were the best places to find the disease. Using the best combination of factors (stain and body part), and the animals with the lightest infections, we calculated that at least 17 sections are needed in order to reach 95% confidence that animal is or is not infected. We conclude that the choice of stain and body part can significantly alter estimates of prevalence of *B. dendrobatidis*.

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Detecting effects of disturbance in the longterm fish assemblage of the Wabash River

The fish assemblage of the Wabash River has undergone major changes during the past several decades. We document these changes through two approaches using collections from 1974--1998. We test if the fish assemblage exhibits stability or directional change in response to disturbance with a modified time series analysis. Multivariate analyses are used as an additional test for concordant patterns of changes in the assemblage through time at individual sites. Collections at sites are examined for variation in longterm trends related to hydrological alteration.

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Digestive enzyme activities in anuran tadpoles under varying food conditions

Aquatic tadpoles encounter foods that vary in terms of nutritional value and quality. Studying digestive enzymes of tadpoles gives insight into their capabilities to consume and digest differing foods available at unpredictable intervals. We compared digestive enzyme activities in tadpoles of the Wood frog (*Rana sylvatica*) and the American toad (*Bufo americanus*) exposed to changing diets. Throughout the 108 hour experiment after a 12 hour acclimation period, the diets fluctuated from algae (carbohydrate), to shrimp (protein), and back to algae (carbohydrate) with equally divided feeding periods on each food. This investigation is the first to report evidence of digestive enzyme plasticity in larval anurans. The levels of amylase and trypsin activities varied between species and among time periods; both enzymes were more active in *B. americanus*

than in *R. sylvatica*. Pepsin had the lowest specific activities and was not significantly different between species. Lipase did not vary across time periods or between these species throughout the experiment. Trends in the levels of carbohydrase and protease activity varied with different foods consumed across the experimental periods, indicating that enzymatic plasticity is present for these tadpoles as diet shifts. Knowledge of tadpole digestive enzymes can help in deciphering the physiological changes that must take place for these animals to reach metamorphosis, when encountering unpredictable environmental food resources. **SSAR SEIBERT MORPHOLOGY & PHYSIOLOGY**

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An Initial Assessment of the Fish Community and Habitats Within a Proposed Outer Continental Shelf Marine Protected Area off North Carolina with comparisons to nearby hardbottom communities

Marine protected areas (MPAs) have been proposed for numerous areas along the southeastern United States continental shelf to help manage the snapper-grouper complex, particularly deepwater species. The MPA proposed off North Carolina includes shelf-edge hardbottoms and a shipwreck, known as the Snowy Wreck. During 2001-2004, sampling was conducted (57-253 m) to describe habitats and fish communities within and outside of the North Carolina proposed MPA (p-MPA) using the Johnson Sea-Link (JSL) submersible, remotely operated vehicles (ROVs), otter trawls, and hook and line. Three general habitats were observed with the JSL and ROV: high relief hardbottoms (HB), low-relief boulder fields (BF), and soft substrate habitats (NH). From HB habitats and the Snowy Wreck, 113 fish species were documented. From NH habitats, 34 fish species were documented. A few species inhabited a wide depth range, many species occurred only at shallower (≤ 125 m) sampled depths, and other species were observed only at the Snowy Wreck (238-253 m). *Anthias nicholsi* and *Epinephelus niveatus* were the most abundant species at the Snowy Wreck. Anthiines were abundant on HB habitats, and triglids, peristediids, and synodontids were abundant on NH habitats. Members of the commercially fished snapper-grouper complex, such as *Haemulon aurolineatum*, *Mycteroperca phenax*, and *Rhomboplites aurorubens*, were abundant on HB habitats. Several behavioral observations and two new range extensions, *Serranus chionaraia* and *Lythrypnus elasson*, were noted. Few differences were observed within and outside of the p-MPA. The low relief BF habitat, observed only outside of the p-MPA, appeared unique in habitat type and relative abundance of fishes compared with other HB habitats. This study has added knowledge on habitat and species distribution on shelf-edge reefs off North Carolina. Future work on these reefs is needed; however, data suggest that the boundaries of the North Carolina p-MPA be re-examined to include more known shelf-edge hardbottoms.

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Phylogenetic relationships among and phylogeographic patterns within rare pygmy sunfishes

Pygmy sunfishes (*Elassoma*) are primarily lowland species with an interesting biogeographic dichotomy: three species have broad geographic distributions, and three are narrowly distributed (and have been recommended for threatened or endangered status). To test phylogenetic predictions derived from the geographic distributions of pygmy sunfishes and possible historical factors contributing to the threatened/endangered status of the rare species, we reconstructed trees for two mitochondrial genes and introns of three nuclear genes. The pattern and rate of nuclear and mitochondrial sequence evolution was heterogeneous within *Elassoma*, but relationships were generally concordant across gene trees. Notably the relatively rare *E. boehlkei* and *E. okatie* are sister taxa, and are related to a widespread species, *E. evergladei*. We investigated this relationship through broader sampling of *E. boehlkei* and *E. okatie*. The phylogeographic partitions observed within these rare species are compared to comparable data on several species collected in the same river systems.

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Growth and reproduction of *Centroscyrnus coelolepis*, *Centrophorus squamosus* and *Prionace glauca* off the Portuguese coast

In March 2003 a monitoring program was implemented on the four main Portuguese landing docks, aiming at obtaining growth and reproduction data on the most frequently landed benthic (*Centroscyrnus coelolepis* and *Centrophorus squamosus*) and pelagic (*Prionace glauca*) shark species. While length-frequency analyses failed to produce a good estimate of age and growth for benthic species due to lack of smaller individuals, growth parameters for *P. glauca* were estimated as: $K=0.11$, $L_{inf}=238.29\text{cm}$ (for females) and $K=0.18$, $L_{inf}=221.60\text{cm}$ (for males). *C. squamosus* males are sexually active throughout the year and maturation occurs between 96 and 105cm total length; *C. coelolepis* male maturation occurs around 85-90cm TL. A summer breeding season for *P. glauca* is proposed for the north-east Atlantic, with males maturing at 198cm fork length. These species have a late maturation and 95% of the landed sharks were immature.

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Preliminary results from an investigation of rattle loss in island rattlesnakes

Complex features are the product of the integration of the behavioral, morphological, and physiological components that comprise the feature. Vestigialization of the feature involves a reduction of these components and possibly a breakdown of their integration. However, little is known about how the components of a complex feature break down in relation to each other. The rattle of rattlesnakes is considered to be a complex feature and its evolution involved a number of changes in rattlesnake behavior, morphology, and physiology. Three island rattlesnake species endemic to islands in the Sea of Cortez are known from primarily qualitative reports to have reduced rattle morphology, but little is known of their rattling behavior or their physiological capacity for rattling. After only one field season, quantification of rattling components in island species has revealed significant differences when compared to their mainland relatives. The morphological substrate for the behavior (the rattle) was reduced, but because rattling behavior was present in both species and rattle vibration frequencies were not reduced in either species, morphology appears to have become decoupled from behavior and physiology under vestigialization and may be the first component to show reduction when a complex feature degrades. In the rattling system, it appears that loss of form does not completely correlate with a loss of function; the context in which rattling was used and the physiological capacity to produce rattling are not altered. However, loss of form does appear to correlate with a complete loss of function of the rattling system as a whole, complex feature. **STORER HERPETOLOGY**

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Efficacy of three types of arboreal traps

Herpetile populations are sampled in a number of ways, including visual encounter surveys, road transects, and listening posts. One of the most frequently employed techniques is terrestrial trapping (i.e., drift fences with pitfall traps or funnel traps). However, several studies suggest that arboreal herpetofauna are under-represented in surveys because they are able to evade capture by climbing out of pitfall traps or over drift fences. This study evaluated the effectiveness of three types of terrestrial traps modified for arboreal application: a pitfall trap, a glueboard, and a drift fence. Twenty-four groups of the 3 trap types were placed in trees on two sites: a military training base in Parker County, Texas, and a ranch in Mason County, Texas. Data were collected from August 2003 through August 2004. Six and 26 animals were trapped on Fort Wolters and Taylor Ranch, respectively. Small mammals were captured most often (22), with fewer herpetile (7) and bird (3) captures. The pitfall trap caught the most animals (26) whereas glueboards and drift fences caught five and one individuals, respectively. No traps failed during the experiment. Pitfalls and glueboards required little time and effort to assemble and were quickly

deployed. Glueboards required biweekly replacement. The arboreal drift fence required near-constant maintenance and assembly was difficult and protracted. We do not recommend the use of arboreal traps in savannah habitats. However, pitfalls and glueboards may be viable options for further research in other habitats.

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Evidence of extensive mitochondrial introgression in the Redfin Shiner, *Lythrurus umbratilis*

In 2004, we presented preliminary cytochrome-*b* data collected to investigate the identity of a potentially novel form of the Redfin Shiner, *Lythrurus umbratilis*, in the upper Ouachita River, Arkansas. In the course of analyzing these data, it was hypothesized that specimens collected from this system likely exhibit mitochondrial introgression with *L. snelsoni*. In widening our sampling scheme, we have uncovered additional evidence for introgression of these species throughout the Atchafalaya River basin. Further, we hypothesize that an additional introgression event has occurred with *L. fasciolaris* in the eastern portion of the Redfin Shiner's range. These events may or may not coincide with the recognized subspecies of *L. umbratilis*. Additional sampling, both geographic and genetic, is needed to determine the extent of introgression, gain more robust hypotheses of the relationships of populations currently comprising *L. umbratilis* to other nominal *Lythrurus* species, and determine the degree of polytypy among those populations. Extensive cytochrome-*b* data will be presented with a discussion of future research directions to further investigate the status of the distinctive upper Ouachita form.

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Atypical reproductive cycle of the viviparous lizard *Sceloporus grammicus* (Squamata: Phrynosomatidae) from Tepeapulco, Hidalgo, México

In this study we present some reproductive characteristics of the lizard *Sceloporus grammicus* from Tepeapulco, Hidalgo México. The data were collected from July 2003 to June 2004. The objective of this study was to know some reproductive characteristics of *S. grammicus* such as minimum snout-vent length (SVL mm) at sexual maturity in both males and females, reproductive cycle of males and females, litter size, correlation between litter size and females' SVL, sexual

dimorphism, and to compare these reproductive characteristics of this population with other populations previously studied. Males and females reached sexual maturity at a SVL of 43 mm and 42 mm, respectively. Reproductive activity of both sexes was atypical. Testes mass started to increase in size from September to October and the maximum mass was registered from November to July and decreased in August. In contrast, female reproductive activity did not follow a pattern. Vitellogenic follicles and embryos were found through the year. Mean litter size was 5.1 ± 0.25 (2– 8). There was no significant correlation between SVL of the females and litter size ($P = 0.6548$). Males were larger in head length (mm), head width (mm), forearm (mm), tibia (mm), and femur length (mm) than females ($P < 0.005$). Some reproductive characteristics of females are similar to other populations but different in the reproductive cycle of males and females. These data suggest that this population responds not only to the environment, but also to the phylogenetic influence.

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Dental biomechanics in the Whitespotted Bamboo Shark (*Chiloscyllium plagiosum*): A novel mechanism for varying tooth function

Whitespotted bamboo sharks (*Chiloscyllium plagiosum*) feed upon soft prey, fishes and squid, and possess the characteristic clutching type dentition that is well suited for grasping and holding such prey. In contrast, they also feed upon hard prey, such as crabs, repeatedly crushing and breaking them into several pieces prior to swallowing. The ability to process hard prey is not typically associated with clutching-type dentitions. Tooth mechanics during capture and processing of these contrasting prey types (hard and soft bodied) requiring functionally different tooth morphologies is presented in *C. plagiosum* based on anatomical dissection and manual manipulation of teeth and associated tissues. Teeth of *C. plagiosum* are loosely attached to the jaws allowing movement in both sagittal and frontal planes; a feature noted in many other species of elasmobranchs, including carcharhinid sharks and white sharks, *Carcharodon carcharias*. During prey capture, the spike-like tooth cusps are used for piercing the flesh of captured soft prey, thereby preventing escape. Tension generated in the dental ligament during jaw protrusion and adduction may counter the flexible tooth attachment and fix the teeth in an erect position; facilitating the puncture of soft prey. Alternatively, when feeding on prey harder than the teeth can pierce, the teeth passively fold inward towards the oral cavity (depress) such that the broad flat labial faces of the teeth are nearly parallel to the surface of the jaws and are used as a crushing surface. Movement into the depressed position increases the tooth surface area contacting prey and decreases the total stress applied to the tooth; therefore, decreasing the risk of structural failure. This mechanism suggests that flexible tooth attachment may be a functionally beneficial adaptation in *C. plagiosum* that allows for an increase in dietary breadth, and is not merely a by-product of rapid tooth replacement.

***RAMSDEN, CADHLA; BOGART, JAMES P.**

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Success through flexibility: Examining the unique reproductive mechanisms of the unisexual *Ambystoma* complex of mole salamanders

There has been chronic confusion surrounding the evolutionary history and unique reproductive success of the all-female, polyploid -hybrid-lineage of the mole salamanders of the *Ambystoma* complex. Members of this unisexual lineage have been shown to contain a mitochondrial genome derived from *A. barbouri*, while the nuclear genome of the unisexuals includes genomic contributions from up to four species: *A. jeffersonianum*, *A. laterale*, *A. texanum* and *A. tigrinum*. Further, the unisexual lineage has been determined to be of recent origin, but is geographically widespread and ecologically successful. To better understand the evolutionary trajectory of this unusual lineage, the breeding system of the unisexuals was examined using microsatellite markers to genotype the offspring of known triploid and tetraploid females. We found that these females exhibit characteristics of both asexual and modified sexual reproductive processes which enable them incorporate the genomes of any of the bisexual members of the complex they come into sympatry with. This information sheds new light on the unusual ecological and evolutionary success of this unisexual lineage.

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Ecology of the Atlantic gobies *Nes longus* and *Ctenogobius saepepallens*

The symbiotic association of the western Atlantic gobiid fishes *Nes longus* and *Ctenogobius saepepallens* with the snapping shrimp *Alpheus floridanus* is re-examined on the basis of literature review and new data. Our research confirms that *N. longus* interacts closely with the shrimp and is dependent on it for the cover provided by the burrow that the shrimp constructs; the goby serves as the sentinel at the burrow entrance. *C. saepepallens* is often seen occupying a burrow of the alpheid, and the shrimp will leave the burrow to deposit sediment with the goby at the entrance, even pushing the goby aside at times. However, the shrimp does not make contact with the goby with its antennae, nor does the goby communicate by caudal-fin fluttering at the approach of danger. It is suggested that their relationship is a first step in an evolutionary process that may lead to closer association. The food habits of the two gobies are compared.

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Relationship between recruitment of Gulf sturgeon and water flow in the
Suwannee River, Florida, USA

A 19 year mark-recapture database was used to estimate yearly recruitment of Gulf sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee River, FL, USA, using a length-age equation derived from known-age fish. Yearly recruitment information was transformed into a relative year-class strength index, which was analyzed against monthly river flow. Recruitment was positively correlated with high monthly mean flow in December and September. It is postulated that the correlation is the result of increased survival of late-winter estuarine-feeding age-0 juveniles during high-flow years.

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The response of a 'putty' species to intraguild removals: interactions
among salamanders

A diverse array of plethodontid salamander species inhabits the Appalachian mountain region in the southeastern United States. Past studies at Mountain Lake Biological Station have demonstrated that abiotic factors (e.g. moisture levels) influence the localized distributions of several species of salamanders, with *Plethodon cinereus* found far from streams, adults of the genus *Desmognathus* near streams, and *Eurycea cirrigera* found, on average, somewhere between. It is possible that biotic factors such as competition may also influence the localized distributions of these species. *Eurycea cirrigera* appears to be a 'putty' species, and potentially is able to occupy a diverse range of niches, although the presence of other species may restrict the niche use of *E. cirrigera*. In the presence of *Desmognathus* and *P. cinereus*, both highly aggressive species, *E. cirrigera* appears to be marginalized, reducing its habitat niche away from both streams and woodlands. In this field experiment, we will remove three species of *Desmognathus* from some plots, *P. cinereus* from some plots, both *Desmognathus* and *P. cinereus* from some plots, and some plots will serve as controls. One hypothesis is that *E. cirrigera* will respond 'favorably' if either *P. cinereus* or *Desmognathus* is removed (increase in numbers, be found further from/closer to streams). A second hypothesis is that competitive/predatory interactions between *Desmognathus* and *P. cinereus* open a niche for *E. cirrigera*. This hypothesis would be supported if *E. cirrigera* decreases in density after *Desmognathus* removal (potentially due to increased competition from *P. cinereus*). With the null hypothesis, *E. cirrigera* will not demonstrate any response to removals of the other salamanders.

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Angels with barbelled faces: a fanciful new heptapterid catfish from Brazil

We report the discovery and salient characteristics of a remarkable new heptapterid catfish that is distinctive in its greatly hypertrophied and fanciful dorsal fin. We tentatively place this angelic species in the genus *Pimelodella*. The seven known specimens range from 165-340mm SL making this species one of or the largest *Pimelodella*. This species shows a remarkable development of all the dorsal-fin rays: the dorsal-fin spine has a flexible extension, longer than the spine itself; the second and third rays are the longest and approximately three times the size of the hard dorsal-fin spine. This largest specimen is a sexually mature male, with well developed testes, suggesting that the dorsal-fin development might be a secondary sexual dimorphism. These specimens were collected from two tributaries of Rio Guaporé: Rio Novo and Rio Cautário (Reserva Extrativista do Rio Cautário), in an area of median elevation (Serra da Cutia, Rondônia State, western Brazil).

RASTEGAR-POUYANI, NASRULLAH

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Systematics of the *Laudakia caucasia* species complex (Sauria: Agamidae): A multivariate approach

The *Laudakia caucasia* species complex, as one of the western radiations of its relevant genus, has traditionally been recognized by three taxa at the subspecific level: *Laudakia caucasia caucasia* (Eichwald, 1831), *L. c. microlepis* (Blanford, 1874) and *L. c. triannulata* (Ananjeva and Ataev, 1984). In order to re-evaluate this traditional judgement and to resolve the patterns of geographic variability within and among the three above-mentioned taxa by the use of multivariate techniques as clearly as possible, cluster analysis, principle component analysis, and canonical variate analysis were employed using the most informative characters pertaining to scale morphology, body stature, and coloration. All the analyses showed a clear difference between *L. c. microlepis* on the one hand and *L. c. caucasia-triannulata* on the other, and identified two primary groups of individuals corresponding to *L. c. microlepis* and *L. c. caucasia-triannulata* respectively. Collectively each group showed a high degree of morphological distinctiveness. For instance, 93% of males of *L. c. microlepis* and 85% of males of *L. c. caucasia* were assigned to their correct a priori group by a Jackknifed classification in canonical variate analysis. This was just 18% for *L. c. triannulata*, emphasizing the lack of morphological distinctiveness in this traditional taxon. The results of these analyses confirm my previous judgement on the taxonomic status of the *L. caucasia* species complex and show that the conventional tripartite division of this complex is artificial, not portraying the actual patterns of speciation, classification, and geographic variability. In short, based on this study it is evident that the traditional *L. c. microlepis* is quite distinctive and warrants taxonomic recognition at the specific level, and that *L. c. caucasia* and *L. c. triannulata* are very similar in all pertinent details, belonging to a single

taxonomic entity. So, the use of trinomen *L. c. triannulata* should be discontinued and all the populations of these two traditional subspecies (*L. c. caucasia* and *L. c. triannulata*) come under the name *L. caucasia*.

RASTEGAR-POUYANI, NASRULLAH

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Systematics, distribution and ecology of the *Ophisops elegans* complex (Sauria: Lacertidae) in Iran.

The snake-eyed lizards of the genus *Ophisops* Menetries 1832, encompass about 9 species occurring from southeastern Europe into the Middle East and north Africa and as far east as northeastern India and Bangladesh. Of these, so far, only one species complex, *Ophisops elegans* complex, has been recorded from Iran. This complex consists of two traditional subspecies in Iran: *O. e. elegans* with two postnasals and *O. e. blanfordi* with just one postnasal. The former subspecies occurs in most parts of the Iranian plateau, except the southwestern regions in which the later taxon is occurring. Exact distributional range of these two subspecies are determined and it is shown that in some regions of southern Zagros the two subspecies have a narrow contact, producing hybrid individuals. Based on this study, the specific status of *Ophisops blanfordi* is questionable and this taxon is considered just as a subspecies within the *Ophisops elegans* complex. Some ecological factors in relation to distribution and range expansion of this lizard are mentioned and it is concluded that various biotic and non-biotic factors are in effect to shape the patterns of distribution of this complex on the Iranian Plateau. Distribution maps of the two subspecies are given and a key to these taxa are provided.

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Snakes gorging on gobies: Positive impacts of an invasive species on a threatened snake

The North American Great Lakes have served host to nearly 200 exotic species invasions over the past several decades. Invasive species often are associated with rapid and far-reaching negative impacts on populations and ecological communities. In contrast, long-term studies on federally threatened Lake Erie watersnakes (*Nerodia sipedon insularum*) have demonstrated beneficial effects of the recently introduced round goby (*Neogobius melanostomus*). Round gobies invaded western Lake Erie in 1995 and were documented in the diet of watersnakes as early as 1996; by 2004 over 92% of watersnake diet consisted of round gobies. This dramatic diet shift has led to an increased growth rate in adults and an increased body size in adult and juvenile watersnakes. These factors may contribute to increased offspring production and reduce time to sexual maturity, two factors that may speed the recovery of the Lake Erie watersnake subspecies.

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Defensive behaviors in Neotropical snakes: An interspecific comparison

Snakes exhibit a variety of behaviors to discourage potential predators. These include crypsis, striking or biting, flight, mimicry, and adaptations to enhance apparent body size or protect critical regions of the body. Comparative studies of defensive behavior may reveal ecological patterns that reflect habitat-specific suites of predators or efficacy of signals. Although the diversity of Neotropical snakes is extremely high, few detailed studies of their defensive behavior have been conducted. We used cluster analyses to investigate ecological and phylogenetic trends in the defensive behaviors of Amazonian snakes, based on both original observations (17 species) and published sources (over 75 species). Defensive behaviors tend to differ between arboreal and terrestrial species. Many behaviors, such as head-hiding and biting, have evolved independently in several lineages of snakes. This study provides additional documentation of defensive behavior in several ophidian species. Future studies would benefit from the development of standardized methods for eliciting and recording defensive behaviors in snakes.

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Spatially explicit examination of juvenile Gopher Tortoise (*Gopherus polyphemus*) habitat preferences in a Florida sandhill

Public lands are becoming increasingly important to the continued survival of the gopher tortoise, making it imperative that land managers know the specific habitat requirements of both adult and juvenile gopher tortoises. Little is currently known about environmental factors that underlie hatchling and juvenile survival and recruitment in gopher tortoise populations. Because of the short duration and distance of juvenile tortoise foraging journeys, food availability near the burrow may considerably affect juvenile growth and survival. Juvenile tortoises need more nutritious food than adult tortoises for growth, and predation pressure and thermoregulatory constraints unique to juvenile tortoises prevent them from foraging long distances in search of food in low-quality habitat. Thus, juvenile gopher tortoises with burrows in high-quality habitat will have a selective advantage. This two-year study of a central Florida sandhill examines the spatial and temporal relationship between juvenile gopher tortoise burrows and the surrounding habitat. Gopher tortoise burrow positions, activity, and width were recorded in four complete surveys of the 4-hectare study area. Coincident with three of the burrow surveys, vegetation and structural habitat characteristics, such as forb and canopy cover, were surveyed in a regular design. Spatial point pattern analysis was used to examine the differences and relationships between burrow positions within and between

survey periods. Vegetation parameters were interpolated from quadrats into continuous layers over the study area and then combined into a single layer representing the probability of burrow presence, using values of vegetation characters that the literature indicates are preferred by juvenile tortoises. Monte Carlo point patterns were generated from the vegetation probability layer and compared to empirical burrow patterns. These methods will help identify habitat characteristics associated with active juvenile gopher tortoise burrows that can be used by public land managers to improve existing tortoise habitat and to identify high-quality habitat for future preserves.

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Effect of trapping density on the physiological stress of slider turtles (*Trachemys scripta*)

Baited traps are used in most turtle studies because they are a reliable and cost effective way to obtain turtles. Although it has been demonstrated that trapping itself is not an acutely stressful event, no studies have examined how the density of turtles in traps affects stress levels. This can be a major concern because, in productive areas, multiple turtles are often caught in one trap and may spend up to 24 hours in a trap. If crowding is acutely stressful to turtles, it would result in elevated baseline corticosterone levels. In this study, we examined the effect of trapping density (1, 2, 3, 4+ turtles per trap), sex, and body condition on the baseline corticosterone levels of turtles captured in baited hoop traps. The results from this study are valuable for future studies examining hormones and stress in aquatic turtles.

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Ontogenetic divergence in sexual dimorphism and sexual maturity in aquatic turtles, are general methods enough?

Accurate identification of life history variables such as sex and maturity are essential for demographic studies. In turtles, secondary sexual characters are often used to define these important variables. The general method uses the smallest male that exhibits secondary sexual characters in a population as a reference. Individuals lacking secondary sexual characters and are smaller than that male are designated as juveniles, and individuals that are larger are designated female. The size at differentiation or maturity in that population is also utilized among other populations and even sub-species. We predict that

such generalizations in the methodology used may result in erroneous classification of sex and maturity, especially in smaller and/or younger individuals with less developed characters. In this study, we use the slider turtle (*Trachemys scripta*) to test the accuracy of such a generalized methods in differentiating between sexes at the beginning of morphological divergence of secondary sexual characters, and examine if morphological divergence of secondary sexual characters correlates with physiological maturity in these turtles.

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The green turtle: Historical and current patterns in phylogeography and relevant implications for conservation planning

I present both historical and current patterns of phylogeography and the value of making conservation priorities based on observed patterns. The green turtle is a globally distributed subtropical and tropical nesting species. I discuss historical patterns of major population contractions and expansions following glacial cycles over the last three million years. I provide estimates for historical and current population sizes and discuss the effects of global climatic cycles on tropical nesting marine turtles. This historical perspective of green turtle response to global climate change is translated into suggestions for long-term conservation planning in the wake of anthropogenic climate change. In terms of current patterns of phylogeography, green turtle life history is characterized by complicated migratory pathways and long maturation periods. Age class-specific aggregations of immature green turtles occupy specific marine habitats. As juveniles, green turtles from mixed source rookeries recruit to juvenile foraging areas for 5-10 years prior to reaching reproductive maturity. Juvenile green turtles are also afflicted with a potentially life-threatening herpes virus-associated disease known as fibropapillomatosis. I combine molecular genetic data on three juvenile green turtle foraging areas with detailed epidemiological surveys. Current patterns in phylogeography, like the historical patterns discussed above, have direct implications for conservation planning. I incorporate current patterns of phylogeography, elucidated through molecular genetics and Bayesian MCMC mixed stock analyses, with ecological and epidemiological parameters to predict the effects of this disease on contributing rookeries, which depend upon these foraging areas for adult recruitment. I then suggest conservation strategies which would manage for the effects of this disease decades into the future. These suggestions for conservation planning serve as examples of the how we can utilize patterns of historical and current phylogeography as guidelines for the recovery of threatened and endangered species.

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Ecology and conservation of *Boa constrictor* in the Cayos Cochinos, Honduras

Insular snakes are increasingly held up as model systems for investigations of evolutionary shifts and/or plasticity in body size, and their typically high densities may offer high returns on sampling effort relative to mainland populations. Some insular snakes are of conservation concern because their often unique appearances and divergent body sizes make them highly desirable in the pet trade. During July-September 2004, we initiated a long-term study of insular-endemic *Boa constrictor* in the Cayos Cochinos, an archipelago off the north coast of Honduras. Due to their small size and attractive pattern, these snakes were heavily exploited for the pet trade during the 1980's, and we estimate that >10 boas/ha were removed from the islands during this time. Fieldwork was primarily pursued on Cayo Menor (which is protected as a biological reserve), with additional sampling on Cayo Mejor (with a permanent human population). We captured 84 *B. constrictor* during our fieldwork on Cayo Menor, with snout-vent lengths ranging from 64cm to 205cm. Low capture rates on Cayo Mejor suggest that this population has been depleted by exploitation for the pet trade. Results of a radiotelemetric study of four boas indicate that snakes are highly arboreal and make extensive use of tree cavities as refugia. Most boas were captured in oak hill forest, and only one boa contained a prey item. Overall, our results are consistent with previous work on other island populations suggesting that these boas fast for long periods and largely subsist on migratory passerine birds in the spring and fall. The summer months may represent a period of low prey availability and moderate water stress. Recent arrests of snake smugglers indicate that exploitation of these boas continues, and that Cayo Menor may be the only sanctuary for this unique population in the long term.

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Energy flow and nutrient cycling associated with ambystomatid salamanders in Illinois ponds and adjacent forest

Breeding adults and metamorphosing larval amphibians transfer materials between freshwater and terrestrial ecosystems during seasonal migrations and emergences, although rarely have energy flow and nutrient cycling associated with different life stages been quantified. During 2002-2004, we intensively sampled ambystomatid salamander assemblages in five forested ponds in southern Illinois to quantify energy and nutrients associated with egg deposition, larval production, and emergence of metamorphosed larvae. Adult breeding salamanders represented standing stocks ranging from 1.9-417.7 g C ha⁻¹ (0.5-110.0 g N ha⁻¹) for assemblages and 1.9-406.9 g C ha⁻¹ (0.5-107.1 g N ha⁻¹) for populations, and was highest for *Ambystoma maculatum*. Oviposition by female salamanders added 3.8-554.8 g C yr⁻¹ (0.7-105.7 g N yr⁻¹) to ponds. Carbon cycling associated with larval production ranged from 0.05-3.8 g m⁻² yr⁻¹ (0.01-

1.0 g N m⁻² yr⁻¹) in three ponds that did not dry during development, with as much as 4.0 g m⁻² yr⁻¹ (1.1 g N m⁻² yr⁻¹) produced by an entire assemblage. Emergence production averaged 21% (range=2-100%) of larval production; larval mortality within ponds accounted for the difference. Hydroperiod and intraguild predation limited larval production in some ponds, but emerging metamorphs exported an average of 35.6±10.0 g C yr⁻¹ (range=10.0-91.7 g C yr⁻¹) and 9.4±2.6 g N yr⁻¹ (range=2.7-24.2 g N yr⁻¹) from ponds to surrounding forest. For the three ponds where larvae survived to metamorphosis, salamander assemblages provided an average net flux of 212.0±60.4 g C yr⁻¹ and 37.6±11.0 g N yr⁻¹ into pond habitats. Our study is one of the first to quantify the contribution of salamanders to energy and nutrient budgets of ponds and demonstrates the influence of hydroperiod and species composition on fluxes between aquatic and terrestrial habitats. **STOYE ECOLOGY & ETHOLOGY**

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Catfishland, or the Brazilian leg of the Trans-Continental Catfish Expedition sponsored by the All Catfish Species Inventory

The Trans-Continental Catfish Expedition took place during July 2004 across central South America, covering almost 8,000 kilometers in both Peru and Brazil. The Peruvian team, coordinated by Mark Sabaj, Hernan Ortega, and Norma Salcedo, crossed the Andes and collected all the way from Lima to the border with Brazil at Rio Acre. The Brazilian leg of the expedition had ten participants in three collecting vehicles (including a truck carrying a boat, camping equipment, and collecting gear), and dug for catfishes from the upper Rio Paraguay to the Rio Acre, working mainly in the basins of the Paraguay, Tapajos, Madeira, and Purus rivers. Both legs of the TCCE had outstanding results in collecting undescribed catfishes. The Brazilian team collected around 217 catfishes species, 38 already detected as new to science and 76 not identifiable at the moment. The Brazilian team collected representatives of all Neotropical catfish families except Diplomystidae, Nematogeneidae, and Astroblepidae, which are endemic to other regions of South America. New species collected belong to the families Cetopsidae, Trichomycteridae, Callichthyidae, Loricariidae, Auchenipteridae, Heptapteridae, Pimelodidae, and Pseudopimelodidae. The most striking conclusion of this expedition is the fact that about half of the South American catfishes can not be identified to species level. The presentation will include photos of several of the most spectacular catfish ever seen. The TCCE is part of the All Catfish Species Inventory, funded by NSF.

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A fortuitous chain of events: How the rattle facilitates quantification of key life-history trade-offs in rattlesnakes

The rattlesnake rattle has long been recognized as a record, albeit somewhat imperfect, of somatic growth. Early emphasis on its limitations as a data source is

perhaps responsible for a present lack of interest in the rattle's utility for ecological studies. I argue that the limitations have been overemphasized and I offer a restructured perspective on the rattle as a record of somatic growth. Using the sidewinder, *Crotalus cerastes*, as a model system, I present new methods for quantifying individual segments and demonstrate how important life-history trade-offs can be measured. Most notably, the trade-off between early and delayed reproduction – one that typically presents considerable research obstacles – can be measured with respect to both reproductive output and reduced somatic growth. Because of the unique features of the rattle, these measurements can be made using either live animals involved in field studies or museum specimens.

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Are minnows muddled in murky waters? Effects of turbidity on growth of three *Notropis* species

Anthropogenic disturbances, such as agriculture and dams, have influenced aquatic systems by changing the amount of suspended sediment (turbidity) in streams and rivers. Turbidity can have different short-term and long-term impacts on fishes, including altering spawning behavior, foraging success, predator vulnerability and growth rate. Although many aquatic habitats have relatively low levels of turbidity, several river systems have historically experienced extreme turbidity levels (e.g., Great Plains rivers, Colorado River Basin). Hence, anthropogenic reductions in turbidity levels (e.g., via dams acting as sediment traps) may have negative effects on fishes adapted to naturally turbid environments. I investigated the effects of turbidity on the growth of three minnow species (*Notropis bairdi*, *N. stramineus* and *N. boops*) that occur in environments with contrasting turbidity levels. Experiments were conducted over 60 days in outdoor artificial streams at the University of Oklahoma Biological Station. Each species was tested in six clear and six turbid (50-100 NTU) treatments. Fishes were individually marked with acrylic paint, measured and weighed. Benthic invertebrates, zooplankton and algal growth were sampled to quantify food availability. *Notropis bairdi* (turbid-water species) exhibited significantly higher levels of growth in turbid treatments than in clear treatments. *Notropis stramineus* (clear to intermediate turbid-water species) also grew more in turbid treatments, but the results were not significant. *Notropis boops* (clear-water species) did not grow well in either environment. These results suggest that turbidity can enhance the growth of certain species, however, more research is necessary to uncover the mechanisms underlying this enhancement. Understanding how fishes perform in turbid environments will help us reveal what influence, if any, reduction in suspended sediments have on the decline of turbid river faunas. **STOYE ECOLOGY & ETHOLOGY**

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Microsatellite multiplex panels for genetic studies of three species of marine fishes

The reduced costs for high throughput genotyping associated with PCR multiplexing is useful in a variety applications, including population and conservation genetics of wild or natural populations (e.g., evaluating genetic variation and diversity) and genetics as applied in aquaculture (e.g., parentage assignment, quantitative trait loci identification and marker-assisted selection, assessment and control of inbreeding). We developed multiplex panels of nuclear-encoded microsatellites for three species of marine fishes of interest to both conservation and management of wild populations and to public and private aquaculture: red drum (*Sciaenops ocellatus*), red snapper (*Lutjanus campechanus*), and cobia (*Rachycentron canadum*). Comparison of costs for expendable supplies revealed that tetraplexes and octaplexes reduced expenditures four- and eight-fold, respectively, relative to single-locus PCR reactions. Personnel time also was reduced significantly.

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The discovery of an important winter nursery for the lemon shark, *Negaprion brevirostris*, at Cape Canaveral, Florida

The lemon shark, *Negaprion brevirostris*, is a large coastal carcharhinid with tropical affinities whose early life history has been extensively studied. Along the east coast of North America, known high-value nurseries for this species consist of quiescent lagoons and shallows of south Florida and the Bahamas. Recently, a sizeable population of juvenile lemon sharks has been observed along the Atlantic beaches of Cape Canaveral on the central east coast of Florida. These juveniles aggregate within relatively sheltered longshore troughs along an otherwise high-energy coastline, a behavior that facilitates both visual counts and collection. Biweekly visual surveys along a fixed nine kilometer beach transect have demonstrated that lemon sharks are present in the littoral zone year-round but are most common (in groups occasionally exceeding 300 animals) from November until April. To date, 160 sharks have been captured using cast nets and hook and line. Sizes ranged from 48 - 149 cm precaudal length, with estimated ages of 0.5 to 8.7 years. Limited tag returns demonstrate that a portion of this population is migratory, traveling as far as North Carolina (645 km). The local conditions that facilitate such large aggregations are unknown but Cape Canaveral is considered a climactic transition zone and possesses the most expansive sub-littoral shoals along the Florida east coast. Further, these aggregations are currently protected from harvest within the Kennedy Space Center no-entry security zone. Given the high number of sharks documented and the small area of suitable habitat surveyed to date, Cape Canaveral may eventually be recognized as one of the most important nursery areas for lemon

sharks in the United States.

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Coordination of functional systems in the feeding behavior of molluscivorous wrasses

Prey capture in fishes is a complex behavioral process, from the initial sensory detection of a food item to the final motor output of jaws and fins. Both components have to be synchronously coordinated for successful feeding to occur. Despite traditionally being studied separately, study of the interaction of three functional morphological systems, fins, jaws, and eyes, revealing components of feeding behavior previously overlooked. Comparing patterns of coordination between different species will elucidate conserved and diversified elements of functional morphological systems in fishes. A detailed phylogeny of wrasses (Teleostei: Labridae) now permits detailed testing of evolutionary hypotheses of the function and timing of kinetic systems in this extremely diverse and speciose group of coral reef fishes. Feeding events of three species of molluscivorous wrasses from different tribes were filmed at 250 frames per second with a high-speed digital video camera: *Bodianus diana* (Hypsigenyine), *Tautoga onitis* (Labrine), *Cheilinus fasciatus* (Cheiline). The patterns of coordination between these groups are quite different suggesting that different labrid lineages may have developed different solutions to this feeding strategy. *Cheilinus* exhibited large suction, synchronized with eye movement and a sweeping braking motion with the pectoral fins. *Bodianus* exhibited little jaw protrusion and eye movement, and while the eyes were directed forward, there is not a rapid shift of the eye back to center, as seen in *Cheilinus*. *Tautoga* exhibited long and fast jaw protrusion with a large gape angle, but minimal eye movement, and braking motion that started after jaw protrusion had completed. Future comparisons of more specialized feeding strategies will elucidate how evolutionary divergences affect the kinematic pattern of feeding. Diversity in feeding mechanisms seen in wrasses may reflect broader trends in feeding and locomotor systems in coral reef fishes as a whole.

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Measuring Everglades restoration success through the use of amphibian communities

The Comprehensive Everglades Restoration Plan (CERP) requires the use of

ecological indicators to measure the success of restoration efforts. The Everglades amphibian community is ideal because amphibians are present in all habitats and under all hydrologic regimes in the Everglades. During Everglades restoration, hydroperiod will be changed and the response of ecological indicators will determine success. The objective of this study was to define and measure the membership and area occupancy of amphibian communities across hydrologic gradients, thus allowing managers to evaluate Everglades restoration efforts. This study was conducted in Everglades National Park (EVER) and in Water Conservation Areas (WCAs) 3A and 3B in southern Florida. We established plots along a hydroperiod gradient of 95 to 365 days of inundation/year in open marsh habitats. Amphibian sampling included conducting a ten-minute anural vocalization survey and a thirty-minute visual encounter survey twice monthly at night. We also trapped monthly using PVC pipes (treefrogs) and funnel traps (aquatic amphibians). The trapping and surveys were all conducted in five randomly chosen 20 m radius plots located in each of four strata along the hydrologic gradient. Vocal surveys and VES were conducted from April through October and trapping was conducted year round. Four to 9 species were detected per plot with vocalization surveys. Green treefrogs (*Hyla cinerea*), pig frogs (*Rana grylio*), and cricket frogs (*Acris gryllus*) were the only species of frog heard in all strata. VES enabled detection of species that do not vocalize or that we did not hear vocalizing, such as two-toed amphiumas (*Amphiuma means*) and leopard frogs (*Rana sphenoccephala*). The PVC traps were used extensively by both green treefrogs and squirrel tree frogs (*Hyla squirella*). Funnel traps provided a useful way to sample the aquatic salamanders. We captured greater sirens (*Siren lacertina*), two-toed amphiumas, and peninsular newts (*Notophthalmus viridescens*). The final outcome of this research will be community profiles relating the area occupancy of individual amphibian species to the ecological community along this hydrologic gradient.

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An integrative approach to the conservation of Panamanian golden frogs (*Atelopus varius* and *A. zeteki*)

This study takes an integrative approach to amphibian conservation incorporating both mark-recapture and phylogeographic/conservation genetics approaches with the overall goal of developing a comprehensive conservation plan for Panamanian golden frogs (*Atelopus varius* and *A. zeteki*). Found only in lowland rainforests of Panama, these frogs are threatened by habitat loss, illegal collection, and disease (chytridiomycosis). I hypothesize that these frogs are highly philopatric and have low dispersal rates causing even geographically proximate populations to represent uniquely evolving entities. In this case, a detailed knowledge of the ecological and historical differences among populations will be necessary in developing a successful conservation plan. The goal of the mark-recapture study is to quantify the structures of representative populations by estimating demographic parameters, habitat use, and individual growth rates. The goals of the genetic study are to identify differences in male and female dispersal and characterize the amount and structure of genetic variation within and among populations. This study aims to contribute valuable demographic, genetic, and environmental data relevant to combating the loss of

these endangered species as well as demonstrate the combined utilities of mark-recapture and genetic analyses as an integrative framework for designing effective amphibian conservation programs.

***RICHARDS, VINCENT P.; SHIVJI, MAHMOOD S.**

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Strong population genetic structure in the southern stingray, *Dasyatis americana*, revealed by mtDNA control region sequences

Although over half of all known elasmobranchs are batoids, with many species exploited and several of conservation concern, little is known of their population genetic structure and intraspecific evolutionary history. We report here an assessment of gene flow among geographic populations of the southern stingray (*Dasyatis americana*), a large, recreationally important, demersal batoid that ranges from New Jersey, USA and the northern Gulf of Mexico to southern Brazil. Sequence variation in 648bp of the mitochondrial control region was used to infer patterns of gene flow among Florida and Caribbean populations. Out of 229 animals sampled from six locations, 56 haplotypes were identified and AMOVA results revealed high levels of population structure (overall $ST=0.47$). Gene flow between the Everglades National Park, Florida, and Antigua separated by 2,200km was highly restricted ($ST=0.82$). Restricted gene flow was also apparent over much shorter geographic distances, as a comparison between two Belizean populations separated by just 120km produced a ST of 0.21. Our results highlight that populations of the southern stingray need to be managed as distinct evolutionary units.

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Lipid cycling in blacknose dace (*Rhinichthys atratulus*) populations along a rural-urban gradient

Watershed urbanization results in increased impervious surface cover and major changes in stream hydrology, channel morphology, and ultimately, overall stream habitat quality. While many stream organisms cannot tolerate the habitat changes associated with urbanization, some species persist and even thrive in urban areas; how these populations adapt to urban environments remains largely unknown. As part of a larger study investigating adaptation of stream fish to urban environments we are comparing lipid cycling among populations of a small stream minnow, the blacknose dace (*Rhinichthys atratulus*), across a rural-urban gradient. Many stream fish store lipids during times of resource abundance for use during times of high-energy demand (e.g., reproduction) or resource scarcity (e.g., winter). Among the 447 dace examined to date, lean somatic dry weight of both males and females increased with urbanization. When all fish are considered collectively, physiological constraints appear to set an upper limit on lipid storage at approximately 25% of dry somatic weight.

While temporal patterns of lipid content were qualitatively similar across the rural-urban gradient, during most months dace from urban environments had approximately twice the lipid content as dace from more rural environments. Only during winter was lipid content similar across the rural-urban gradient. Our results suggest that in urban streams resources may be more abundant or of higher quality, or both, and that dace in urban streams store proportionally more energy in the form of lipids.

***RICHERT, JOHN E.; CERVANTES-DUARTE, RAFAEL; GONZÁLEZ-ARMAS, ROGELIO; GALVÁN-MAGAÑA, FELIPE; KLIMLEY, A. PETER**

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Spatio-temporal variability in the tropic ecology of large pelagic fishes in the southern Gulf of California

Shallow seamounts are known to be associated with rich stocks of pelagic fishes. We are currently integrating oceanographic survey, fisheries observation, and ecological analyses to examine how and why pelagic fish utilize seamounts in the southern Gulf of California. The study area spans a 200km transect of offshore waters within the Gulf and includes three major seamounts and several lesser banks as well as the open-water between these pinnacles. Primary productivity and plankton abundance are measured seasonally to record spatio-temporal variability at the base of the pelagic food chain and identify locally productive habitats in the region. Fisheries catch data is used to track species' seasonal migrations into the southern Gulf, monitor movements between local hot spots, and relate these movements to oceanographic conditions. Gut contents of ten large, pelagic species, including tunas, billfish, jacks, and dolphinfish, are simultaneously analyzed to determine dietary overlap as well as detect dissimilar feeding habits between species and between sites. Gut contents collected at different seamounts are compared with each other as well as with samples collected from open-water areas. These diet analyses are related to oceanographic surveys in order to compare feeding at sites with higher and lower primary productivity. We are also using stable isotopes of nitrogen (^{15}N) to determine trophic structure among pelagic fish communities. We are using oceanic nitrate levels and stable isotope data from trophically diverse fishes to construct a nitrogen isotopic map for the region and to determine the utility of stable isotopes in the study of pelagic fish migration and food webs. Preliminary results and potential implications of this ongoing study will be discussed.

RICHMOND, JONATHAN Q.

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Parallel speciation as a consequence of divergent natural selection in North American scincid lizards

Parallel speciation is a special case of homoplasy where traits determining

mating compatibility evolve repeatedly in separate lineages experiencing similar environments. The outcome of such parallel evolution is that ecologically divergent but closely related populations show higher levels of reproductive incompatibility than ecologically similar but distantly related ones. I am currently studying a candidate example of parallel speciation in scincid lizards of the *Eumeces skiltonianus* species complex. This complex is composed of two ecomorphs that differ in body size, coloration, and ecology. Phylogenetic analyses provide strong evidence that a larger, arid adapted ecomorph (i.e. *E. gilberti*) has evolved as many as 3 times from within a smaller, mesic adapted ecomorph (i.e. *E. skiltonianus*). Disruptive selection appears to have facilitated phenotypic divergence, with body size serving as the target of selection. Indirect evidence suggests that two of the *E. gilberti* clades are merging as a consequence of secondary contact in the southern Sierra Nevada, indicating that speciation has occurred through parallel processes. However, to demonstrate parallel speciation, independently derived lineages of the same ecomorph must be shown to be reproductively compatible. Here, I present the results of mate choice experiments to evaluate the contribution of 3 predictor variables (genetic distance, geographic distance, and body size) on the probability of copulation success. I use logistic regression in a Bayesian framework to show that body size is the primary determinant of reproductive compatibility and that geographic and genetic distance have little to no influence on copulation success. These data support a model of parallel ecological speciation and lend insight into the ways in which ecology drives the formation of new species. **STOYE ECOLOGY & ETHOLOGY**

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Detection of historic population declines using contemporary genetic data

Amphibian populations are declining worldwide. Many declines are the direct result of human activities, whereas the causes of others are not obvious. For many regions of the world and for many species, data of population size (both historic and contemporary) are not available and are difficult to collect. Diagnosing the demographic status of populations is a crucial first step in conservation planning. Recently developed genetic analyses allow one to assess the status of populations and whether reductions in size (i.e., bottlenecks) have occurred even when no demographic data exist. These tests examine genetic data for signatures of population bottlenecks using allelic dropout, deviations from mutation-drift equilibrium, and loss of low frequency alleles. I will present a case study of two isolated populations of US Endangered dusky gopher frogs, *Rana sevosa*, one with a known demographic history and one without. I evaluated genetic variation in microsatellite DNA loci for 1997, 2001, and 2004 to test for historic bottlenecks and whether the genetic signature indicated an ongoing and intensifying bottleneck. For the population with unknown demographic history, analyses indicated a small population size with no genetic signatures of bottlenecks. For the other population, a historic bottleneck (pre 1997) and a more recent bottleneck (between 1997 and 2001) were detected. These genetic analyses provide scientists with the ability to determine historic and contemporary status of populations using non-invasively collected tissues from a single year.

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Monitoring the success of translocated populations of Blanchard's Cricket Frog (*Acris crepitans blanchardi*) in Michigan

The dramatic decline of amphibian populations worldwide is an urgent conservation issue. One Michigan species of Special Concern, the Blanchard's cricket frog (*Acris crepitans blanchardi*), is declining at an alarming rate in the northern portions of its range. I have been investigating the natural history of this species in addition to working with the National Amphibian Conservation Center (NACC) at the Detroit Zoo on a translocation project to reintroduce Blanchard's cricket frog into three manmade wetlands at the northern extent of its range. To improve the success of this translocation project, I collected data on population structure, habitat preference and movement of two nearby wild populations in the summer of 2004. I also conducted calling surveys in the May 2004, which revealed several robust populations of cricket frogs, including one site slated for development in 2005. Working with the developer and the Department of Environmental Quality, we successfully removed about 1010 cricket frogs from the threatened breeding ponds before construction began. The animals were released into two Michigan Department of Natural Resource (DNR) parks and a wetland near the NACC at the Detroit Zoo in the fall of 2004. Maps of where the frogs were found in the source wetlands and introduced wetlands will be used to determine the preferred microhabitat of the Blanchard's cricket frog. Data on habitat preference, population structure and movement within the wetlands will be used as baseline comparison data for the translocated frogs and to develop recommendations on habitat modifications for improved cricket frog survivorship for the NACC and DNR. This emergency translocation provides a unique opportunity to gather data on an unexpected translocation of a threatened population. **STORER HERPETOLOGY**

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Phylogeography of the Southern Leopard Frog *Rana sphenocephala*

Patterns of speciation have often been attributed to geographic features and ecological gradients. Phylogeography combines the historical and phylogenetic components of spatial distributions of gene lineages. Amphibians provide a model system to examine fine scale mechanisms influencing phylogeographic patterns due to low vagility, high genetic variability, and conserved morphology. We examined the phylogeographic relationships between populations of the Southern Leopard Frog, *Rana sphenocephala*. *Rana sphenocephala* exhibits a broad geographic range that spans multiple geologically distinct regions, ranging from southern New York to southern Florida and from Texas to southern Kansas.

***RIVAS, GILSON A.; MIRALLES, AURELIEN; SCHARGEL, WALTER; BARROS, TITO; BARRIO-AMORÓS, CÉSAR L.**

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The genus *Mabuya* (Reptilia, Scincidae) in Venezuela: A taxonomic overview

A taxonomic approach to the members of the genus *Mabuya* is taken, in order to delineate their evolutionary units. More than 160 specimens from northern South America (Brazil, Colombia, Ecuador, French Guiana, Guyana, Perú, Surinam and Venezuela) and some Caribbean Islands (Trinidad, Tobago and Margarita Island), deposited in the most representative Venezuelan and foreign museums, were studied. Preliminary results reveal the existence of different populations in the mountainous regions of Venezuelan, which cannot be assigned to any of the five species known from this country (*M. calvalhoi*, *M. croizati*, *M. falconensis*, *M. meridensis* and *M. nigropunctata*), nor to any other neotropical species. These undescribed species are all endemic to the Andean Cordillera and from the Venezuelan Coastal Range. Molecular analysis in preparation will allow us to generate phylogenetic hypotheses for those species and gain a better understanding of the radiation of the genus *Mabuya* at a continental and regional scale. Venezuela seems to represent a key biogeographical location for the genus *Mabuya*, given its position at the junction of the South American, Middle American and Antillean regions.

***RIVERA-VICENTE, A. C.; TRICAS, T.**

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Functional subunit hypothesis in the Scalloped Hammerhead Shark, *Sphyrna lewini*

The functional subunit hypothesis proposes that ampullary canals of the elasmobranch electrosensory system are organized into subgroups with distinct spatial projections that serve different biological functions (electric navigation/orientation, prey and conspecific detection, predator avoidance). The prediction of unique projections was tested by measurement of the spatial coordinates of ampullary pores and corresponding subdermal ampullae on the head of a 2.3 m TL scalloped hammerhead shark, *Sphyrna lewini*, and calculation of each canal vector in 3D space. Ampullary clusters were categorized into four groups: superficial ophthalmic anterior (SOa), superficial ophthalmic posterior (SOp), buccal (BUC) and mandibular (MAN). The dorsal SOp contains the longest canals (3.9-15.2 cm) with horizontal projections almost exclusively at 0° and 135° (ref 0°=rostral, 90°=lateral, 180°=caudal, 270°=medial), and a graded dorsolateral projection up to 60° vertical. Because this subcluster has the longest (and most sensitive) projections in both the vertical and horizontal planes, it is a potential candidate for detection of weak uniform electric fields. In contrast, the

ventral SOP has short and long canals that project radially from the cluster. The SOa contains 55% of the canals in the entire array with strong rostral, dorsal and ventral projections. Due to their extreme rostral position and orientation, the SOa and ventral SOP should mediate orientation to dipole fields of prey positioned near the snout. The BUC cluster at the lateral edge of the cephalofoil contains dorsal and ventral canal projections (0.6-9.3 cm) that show a continuous rotation from 20°-270°. This arrangement may guide turning behavior towards dipole fields that originate from prey or conspecifics. These results are consistent with predictions of the functional subunit hypothesis and await behavioral and physiological confirmation.

***ROA-VARON, ADELA; ORTI, GUILLERMO**

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Characiform phylogeny

DNA sequences from five nuclear gene fragments and the ribosomal mitochondrial genes are analyzed to study phylogenetic relationships among families of characiform fishes. Separate and combined analyses of all available data are performed using several optimality criteria to assess the phylogenetic signal and potential biases of each of these molecular markers. Results are used to test current hypotheses (from previous morphological and molecular studies) and to discuss the biogeographic distribution. Characiforms are strictly freshwater fishes that live in Africa and the Neotropics, but taxa in the separate continental masses do not form reciprocally monophyletic groups. The evidence supports three separate African - South American sister-group pairs, suggesting either widespread and asymmetric extinction in Africa or recent marine dispersals.

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A new born Whale Shark (Smith, 1828) from the Golfo de Morrosquillo, Colombia

An offspring of whale shark, with a few hours born was collected in the Golfo de Morrosquillo, Colombia. This individual is the smallest new born specimen recorded so far: 53 cm total length. The previous record was from 300 fetal specimens, ranging in length from 42 to 63 cm in 1995, in a female that was harpooned off the eastern coast of Taiwan. This finding proves, finally, the ovoviviparity of whale shark. The catch was accidentally made during the dry season (January-May) of 2002, by fishermen with a gill net in the Tinajones mouth of the Sinú River, in the Colombian Caribbean (75°55'26"W, 9°27'03"N). The sample was deposited in the collection of the Natural Marine History Museum of Colombia (INVPEC 3664). The whale shark in some parts of the world is well protected, while in some areas is intensively hunted for its fins and meat. It is listed as "Vulnerable" by the International Union for Conservation

of Nature and Natural Resources (IUCN). This discovery opens a new window about the possibility of the southern waters of the Caribbean being a birthing area during the north summer months.

***ROBBINS, STACEY N.; CHAPMAN, ROBERT W.**

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Can marine protected areas conserve genetic diversity in tomtate,
Haemulon aurolineatum?

The Tomtate, *Haemulon aurolineatum*, is an abundant reef fish found in the western Atlantic and the Gulf of Mexico. The tomtate serves as a major food source for grouper species and are important in transfer of biomass from benthic invertebrates to apex predators. While not targeted as an important fishery in need of protection, their ecological role may have consequences for management policies for other species, especially if those policies involve Marine Protected Area (MPAs). In this study, molecular data are used as a means of evaluating the potential benefits of marine protected areas (MPAs) for tomtate. We sequenced a 638 bp segment of the mitochondrial ND1 region in 722 individuals from nine locations from the southeastern U.S. coast, the Gulf of Mexico, Bermuda and the Caribbean. Analysis of molecular variance indicated that the population structure could be represented by Cayman Islands/Virgin Islands/Puerto Rico, southeastern U.S./Gulf of Mexico, Florida Keys, and Bermuda. Comparisons of individual haplotypes by neighbor joining analysis revealed two distinct clades; the southeastern U.S. clade and the Caribbean clade, however, geographic separation is not complete. Ten of 135 haplotypes from the Gulf and the southeastern U.S. were found in the Caribbean clade and 5 of 98 haplotypes from the Caribbean were found in the southeastern U.S. clade. The Florida Keys were represented in both clades in approximately equal proportions, suggesting that the Keys might be a mixing ground for the separate populations. The Cayman Islands and the Virgin Islands do not share any common haplotypes with Bermuda. The Bermuda population also shows the least amount of genetic diversity indicating limited gene flow with other populations. The data suggests limited genetic exchange among populations and indicates multiple MPAs will be required for effective conservation.

ROBBINS, TRAVIS R.

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Genetic and environmental sources of variation in growth and survival between *Sceloporus* populations in Florida: A common garden approach

Plasticity in life history traits is often examined along elevation gradients or between distant populations where environments are obviously different. Because the climatic gradient associated with latitude in Florida is less extreme, though still marked, it provides an opportunity to examine plasticity in traits at a finer scale. Using populations of *Sceloporus undulatus* and *S. woodi* from both north and south Florida, I examined the influence of environment and source population utilizing a common housing experiment. I incubated eggs and then

raised hatchlings for 8 weeks under identical conditions, subsequently releasing them in the habitat from whence they came for a mark-recapture experiment. In their respective habitats, growth was influenced by species and not latitude of source population. The southern population of each species, however, had higher survivorship. All populations had faster growth rates in the common environment relative to their respective habitats, but only *S. undulatus* populations grew significantly faster. Survivorship in the common environment was opposite that in the respective habitats; the northern populations of each species had higher survival. Microhabitat temperature regimes and food availability were measured at each of the respective habitats and are compared with the constant regimes of the common environment in relation to growth and survivorship. **STOYE ECOLOGY & ETHOLOGY**

***ROBERTS, MARK A.; ANDERSON, CHRISTOPHER J.; BASS, ANNA L.; GRADY, JAMES M.; QUATTRO, JOSEPH M.**

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Temporal variation within and between loggerhead sea turtle (*Caretta caretta*) feeding assemblages along the Atlantic coastal United States based on eight years of data

Loggerhead sea turtles (*Caretta caretta*) are long lived pelagic marine reptiles whose early life history, despite concerted research efforts, is relatively unknown. Following these early "lost years", sea turtles are thought to return to near shore feeding grounds as juveniles. Since no tags are available that would weather the transition from hatchling to juvenile, indirect methods must be used to assess the natal beach origin of juveniles in these feeding grounds. Determining the contribution of individual nesting beaches to feeding assemblages is critical information in creating informed management policies. Several studies have previously assessed juvenile origin for a variety of feeding assemblages. Here we use mtDNA haplotype data to evaluate the natal origin of turtles captured in juvenile feeding grounds along the Atlantic coast of the United States from northern Florida to North Carolina, an area previously recognized as a genetically distinct nesting area. We present data for individuals captured over five years, from 1999-2004, additionally, we compare this data to previously published data for individuals captured within the same area from 1995-1997.

***ROBINS, ROBERT H.; PAGE, LAWRENCE M.**

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Study of variation in western Gulf Slope *Percina sciera* (Percidae)

The Guadalupe Dusky Darter, *Percina sciera apristis* (Hubbs and Hubbs), is endemic to the Guadalupe River system of southern Texas. Largely defined by a

greatly reduced number of preopercular serrae, *apristis* is peripheral to and geographically isolated from all other populations of *sciera*. In number of preopercular serrae, *apristis* differs most from the adjacent population in the Colorado River drainage, which has the most serrae. In this regard, *apristis* appears to be diagnosable as a species. To further investigate the taxonomic status of *apristis*, meristic features and male breeding color of *P. sciera* were examined in seven river basins in Texas. In addition to number of preopercular serrae, *apristis* was found to differ from all other populations examined in possessing more pored lateral-line scales and modified midbelly scales on males. However, these characters and others fail to reveal a clear pattern of variation. In several traits, specimens from the Colorado River are intermediate between *apristis* and other populations of *sciera*; in others, Colorado River specimens are most similar to *apristis*. The patterns of morphological variation are considered in relation to geographic isolation, selection and drift, as well as taxonomy.

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Are sunfish trophic polymorphisms the emperor's new clothes?

The centrarchid sunfishes of North America exhibit many hallmarks of an historic adaptive radiation, but we know relatively little about the causes and early consequences of diversifying selection in this group. Our understanding of the nature of phenotypic variation and prey use indicates that resource use can cause diversifying selection among sunfish taxa. However, these studies can't discriminate whether diversifying selection was a cause or a consequence of sunfish radiation. Trophic polymorphism, an association between phenotype and ecology among morphs within a species, is found in bluegill (*Lepomis macrochirus*) and pumpkinseed sunfish (*L. gibbosus*). Numerous postglacial lake populations contain shallow water inshore forms that coexist with deeper open water forms. Studying the origins of trophic polymorphism can provide opportunities to address whether diversifying selection likely contributed to the sunfish radiation. Simpson predicted that if diversifying selection was a strong force in radiation, then it should cause similar isolated populations to diverge in the same way under similar environmental conditions. We can test this prediction two ways: In space, among contemporary populations from geographically isolated postglacial lakes, and in time, by asking if contemporary trophic polymorphisms replicate aspects of the historic sunfish diversification. Resource use, competition, and predation appear to have all played a role in the evolution of trophic polymorphism in pumpkinseeds. To some extent, phenotypic diversity in trophic polymorphism is similar to diversity among sunfish taxa. We have also found that phenotypically plastic traits have diverged between ecomorphs, suggesting that the plastic aspects of developmental systems are some of the first traits to evolve during adaptive divergence. In these ways, studies of trophic polymorphism are providing insights into centrarchid evolution.

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Food habits of the Longnose Skate, *Raja rhina* (Jordan and Gilbert, 1880), in central California waters

The Longnose Skate, *Raja rhina*, is one of the most important incidental species landed in central and northern California demersal fisheries. However, life history information is extremely limited for this species and aspects of its diet and feeding habits are unknown. Feeding ecology studies can provide researchers with important insights towards understanding potential fishery impacts on marine systems. The primary objective of this study was to analyze the feeding ecology of *R. rhina* off the coast of central California. Specimens of *R. rhina* were collected between September 2002 and August 2003 from fisheries-independent trawl surveys conducted by the National Marine Fisheries Service, Santa Cruz Lab (NMFS-SCL). Of 1,193 longnose skates caught, 527 were female and 666 were male. To date, 116 *R. rhina* stomach samples have been processed, and all prey items identified to lowest possible taxa. For every stomach, the percentage of each prey item by number (%N) and weight (%W) were calculated and averaged to obtain a mean value. These measures were combined with the overall percent frequency occurrence (%FO) to determine the Index of Relative Importance (IRI), represented as %IRI. Preliminary results indicate that the five most important prey items are *Neocrangon resima* (31.7% IRI), *Octopus rubescens* (11.6% IRI), unidentified euphausiids (11.4% IRI), unidentified teleosts (10.7% IRI), and unidentified shrimp (9.6% IRI). *Raja rhina* diet will be further analyzed through comparison of the following intraspecific variables: gender (male/female), depth (shelf/slope), and size class (<600 mm/>600 mm). **AES CARRIER**

***ROBINSON, JACE W.; KING, RICHARD B.; DUVALL, MELVIN R.; BURGHARDT, GORDON B.; CASPER, GARY S.; PLACYK JR., JOHN S.**

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Phylogeography of the northern watersnake, *Nerodia sipedon*, in the Great Lakes region

Post-Pleistocene glacial retreat and formation of the Great Lakes in North America had a profound impact on the colonization routes of extant reptiles and amphibians. These colonization routes shaped the current distribution of reptiles and amphibians, resulting in intraspecific geographic variation. This research focuses on phylogeographic patterns of the northern watersnake, *Nerodia sipedon*, in the Great Lakes region resulting from post-Pleistocene glacial retreat. Specifically, this study tests the hypothesis that formation of Lake Michigan acted as a geographic barrier, forcing a two-front colonization into Wisconsin

and Michigan. The northern watersnake is widely distributed in eastern North America, making it an ideal species in which to test this hypothesis. Currently, complete mitochondrial DNA (mtDNA) sequences for the gene ND2 have been obtained from 55 individuals. From these sequences, 27 unique haplotypes were identified from 25 sites across Illinois, Wisconsin, Michigan, Indiana, Kentucky, Ohio and Ontario, Canada. Statistical parsimony analysis of mtDNA sequences identified two genetically distinct networks that could not be connected at the 95% significance level. Maximum parsimony analysis, including three congeneric outgroup sequences also identified two clades. Moreover, these two clades were entirely consistent with the clades identified by the statistical parsimony analysis, with bootstrap values for eastern and western clades of 79 and 100, respectively. These clades represent a separation of eastern and western groups, supporting a hypothesis of two-front colonization. **SSAR SEIBERT EVOLUTION/SYSTEMATICS**

***ROCHA, LUIZ A.; ROBERTSON, D. ROSS; ROCHA, CLAUDIA R.; VAN TASSELL, JAMES L.; CRAIG, MATTHEW T.; BOWEN, BRIAN W.**

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Recent invasion of the tropical Atlantic by an Indo-Pacific coral reef fish

With the Americas and Africa separating it from the Pacific and Indian oceans, the tropical Atlantic is a relatively isolated biogeographic province. The last natural corridor between the Atlantic and Indian oceans, around South Africa, was closed ca. 2 million years ago with the onset of the Benguela cold water upwelling system. However, here we demonstrate that the Benguela barrier can be breached, and document a natural invasion of the Atlantic by an Indo-Pacific reef goby (genus *Gnatholepis*), probably during a warm interglacial period when tropical water flowed from the Indian into the Atlantic Ocean. An mtDNA cytochrome *b* genealogy indicates that colonization of the Atlantic occurred approximately 120 ± 20 thousand years ago ($d = 0.002$). Coalescent analyses of samples from the western, central, and eastern Atlantic ($N = 133$) indicate that *Gnatholepis thompsoni* has maintained the largest and most stable population in the western Atlantic. The relatively low genetic diversity at Ascension Island ($h = 0.46$) and eastern Atlantic locations ($h = 0.52 - 0.68$) could reflect adverse effects of glaciation in these areas, or, alternatively, recent range expansions. Additionally, the recent appearance of *G. thompsoni* at the Canary Islands during the years with the highest recorded temperatures at those islands (as documented by more than 20 years of visual census surveys), indicates that an ongoing range expansion by *G. thompsoni* in the northeast Atlantic is linked to global warming, and implicates elevated sea temperatures in both contemporary and historical range expansions. These findings show how glacial cycles (and perhaps human induced warming) may influence Atlantic tropical coral reef biodiversity.

RODDA, GORDON H.

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How well do species attributes identified from other invasive taxa fit invasive herps?

One of the greatest challenges facing invasive species ecologists is predicting which species will establish and become invasive. Many authorities have prepared lists of natural history attributes that they associate with invasiveness, but these lists have focused on taxa other than herps (usually mammals or plants). Thus testing these species attributes against those of invasive herps constitutes a statistically independent test of the generality of the identified phenomena. In general, the fit is not very good, though objective criteria for goodness of fit are not readily available for this situation. Perhaps we should not be surprised at the poor fit for herps, as most attributes associated with invasiveness in other taxa do a poor job at predicting the invasiveness of the taxon for which they were compiled. Also, invasiveness in a conflation of several potentially divergent attributes, such as likelihood of being transported, likelihood of becoming established in a new environment, rate of spread in the new environment, and intensity of the ecological distortion caused by the invader. Rats are unlike Brown Treesnakes (and humans) in their fecundity and rate of spread, though both can be ecosystem transformers. Finally, some attributes identified for other taxa (such as small seed size) do not well apply to herps, but do reflect a general attribute (such as propagule pressure) that may help explain herp species invasiveness.

RODRIGUEZ, DAVID

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Multiple paternity in the American Crocodile (*Crocodylus acutus*): A survey from Turkey Point Power Plant

A tremendous sample collection effort supported by Florida Power & Light, spanning more than 7 years, has been accomplished for *Crocodylus acutus* in Florida. Since 1995 every nest at Turkey Point has been surveyed and tissue has been collected from every hatchling resulting in a sample set of approximately 4000 individuals. The next logical step is to analyze the samples and interpret the resulting data in order to reveal the genetic structure of the population. Fortunately, technological advances in DNA analyses can now facilitate the application of that database to addressing questions that may impact the conservation of the American crocodile. The specific information possibly garnered from this unique resource includes paternity, reproductive ecology, demographics and long term trends and/or model construction. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

RODRIGUEZ-PEÑA, CARLOS ML.

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Female urogenital region and male ligastyle in the phylogeny of Poeciliinae

The morphology of the urogenital region of females livebears Poeciliinae and the ontogeny and morphology of the ligastyle in males are very informative for the phylogeny of the group. The vagina might be tubular without lip in *Phalloceros*, *Cnesterodon*, *Pallophychus*, and *Phallotorynus* or with lip in several *Poecilia*, *Girardinus*, *Heterandria*, *Gambusia*, *Neoheterandria*, and *Phallichthys*. The simplest vagina in *Tomeurus* is interpreted as an autapomorphy. The urogenital lip might be well projected outside the body as in some *Poecilia*. A chastity genital papillae is an autapomorphy of *Carlhubbsia*. Two chastity scales are synapomorphies in *Pamphorichthys*, *Pseudolimia*, and *Limia*. A discussion about the relevance of the urogenital region in females as well as the ontogeny and morphology of the ligastyle in males for the phylogeny of Poeciliinae is made.

***ROE, JOHN H.; BRINTON, ALICIA C.**

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The secret terrestrial life of an Australian freshwater turtle, *Chelodina longicollis*: conservation implications for aquatic reptiles

Conservation plans for wetland fauna rarely extend beyond the delineated wetland border despite the importance of terrestrial habitats for many semi-aquatic animals and the potential threats they face when moving overland in human-altered landscapes. In this investigation, we examined terrestrial habitat use and movements in *Chelodina longicollis* in Booderee National Park in southeastern Australia, using radio-telemetry and capture-mark-recapture techniques. *C. longicollis* used terrestrial habitats for numerous behaviors and often for extended periods of time (> 6 months). Most turtles used terrestrial habitats for overland movements among as many as four different wetlands separated by distances of up to 2 km. The habitat use and movement patterns of *C. longicollis* are likely related to its use of ephemeral wetlands, which typically offer abundant resources for brief periods of time when full, but require turtles to seek refuge within or move through terrestrial habitats to other wetlands when dry. Numerous wetlands and intact terrestrial habitats adjacent to and between wetlands appear to be critical components of the landscape for *C. longicollis* and many other wetland reptiles. Failure to consider these landscape-level factors in wetland management plans may neglect the needs of some prominent members of wetland communities.

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Thermal sensitivity in viperine snakes?

It has been suggested that some species of viperine snakes have the ability to detect temperature differences and use this sensory information during prey acquisition. The behavioral responses of three species of pit vipers, five species of true vipers, and two species of colubrids to suspended paired targets of differing temperature were compared. Responses were classified as orients towards the warm target, orients towards the room temperature target, or no orient towards either target. To determine if the experimental apparatus could test for temperature sensitivity of the pit organ of pit vipers, several individual *Agkistrodon contortrix* were tested with their pit organs sham blocked and blocked in random order. The rate of head orients to the warm target versus the room temperature target was statistically significant in all species of pit vipers for which an adequate sample size was available. The rate of head orients to the warm target versus the room temperature target was not significant in any species of viperine or colubrid. Several tested species of true vipers would not orient towards either target, regardless of the number of times tested. The rate of head orients towards the warm target versus the room temperature target was not significant for *A. contortrix* that had their pit organs blocked. The rate of head orients towards the warm target versus the room temperature target was significant for *A. contortrix* that had their pit organs sham blocked. Individuals of all species of pit vipers tested without blocked pit organs sometimes struck at warm targets. These results suggest that pit vipers use pit organs to detect infrared energy and that the tested species of true vipers and colubrids cannot detect differences in temperature, or that they lack specific behavior pathways to react to temperature differences that they may sense.

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Conservation implications of patterns of genetic variation in west Michigan ranid Frogs: Evidence from cytochrome b and 12S rRNA

Intraspecific genetic variability in three species of common West Michigan frogs (*Rana clamitans*, *R. pipiens*, and *R. sylvatica*) was studied through sequence analysis of cytochrome b and 12S rRNA in order to assess whether decay of variability is occurring in association with wetland habitat loss, habitat fragmentation, and colonization of man-made wetland areas. The 305 and 375 bp sequences were determined with direct sequencing of 182 frogs from five localities in four watersheds. Phylogenetic trees were constructed using combined cytochrome b/12S rRNA haplotypes with parsimony and maximum likelihood methods. Frequencies of transitions, transversions, synonymous, nonsynonymous, and position-in-codon mutations were comparable to literature values and were used to assign haplotype difference values. These values were used as a dependent variable in discriminant analysis to predict haplotypes from

GIS-generated landscape features. Uncommon haplotypes of *R. clamitans* and *R. pipiens* in the study areas are primitive with respect to common haplotypes and are absent from all but the most undisturbed wetlands. The *R. clamitans* model is 82% accurate and most errors predict uncommon haplotypes where only common ones are present, an indication that the uncommon forms are not dispersing as effectively into new habitats as the common forms. Of the species studied, *R. pipiens* has the least genetic diversity and *R. sylvatica* has the most. Modeling for *R. pipiens* is 90% accurate but modeling for *R. sylvatica* is only 60% accurate. Uncommon haplotypes of *R. sylvatica* appear to be generated throughout the study area and are not confined only to stable areas of undisturbed preferred habitat.

ROKETENETZ, LARA D.

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Predictive ecological habitat models for the distribution and conservation of *Clemmys guttata*

Clemmys guttata is a species of freshwater turtle whose range extends throughout eastern North America. They are known to inhabit wetland and upland areas throughout their life cycle, and different habitat types are utilized for foraging, breeding, aestivation, and hibernation. Rapid declines in populations throughout its range, due primarily to habitat degradation and overharvesting for the pet trade, continues to require guidance for the conservation of this species, either through state-mandated protection or habitat preservation. Ecological niche models generate maps in geographical space that can accurately depict fundamental niches by predicting those areas that contain suitable habitat for the species in question. These models can be developed through the Genetic Algorithm for Rule-set Prediction (GARP) by finding correlations among known occurrence points and environmental and ecological parameters that predict the distribution of suitable habitat for *C. guttata* throughout its range in North America. Electronic museum specimen data obtained from California Academy of Science; Carnegie Museum of Natural History; Cleveland Museum of Natural History; Field Museum of Natural History; United States Natural History Museum (Smithsonian Institution); The University of Kansas Museum of Natural History; and Texas Cooperative Wildlife Collection were analyzed for suitability in this analysis. Environmental and ecological variables were obtained from the United States Geological Survey, the Intergovernmental Panel on Climate Change, and the University of Maryland. The purpose of this study is to highlight areas of suitable habitat for *C. guttata* utilizing predicted distributions based on the ecological niche models obtained from GARP. Areas that exhibit high correlation of the preferred environmental factors can be geographically determined and examined for potential conservation areas, based on current land use. Additionally, the delineated areas will provide field researchers a resource that emphasizes areas that may have unreported occurrences of this species due simply to sampling error in the past. **SSAR SEIBERT
CONSERVATION**

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Age and growth of the sandbar shark, *Carcharhinus plumbeus*, in Hawaii.

Age and growth of the sandbar shark, *Carcharhinus plumbeus*, in Hawaiian waters were investigated by examining annuli deposited in the vertebral centra from wild animals and mark-recapture methods. Previous research has suggested rapid growth rates not typically associated with populations of sandbar sharks throughout the world. Previous researchers estimated von Bertalanffy growth estimates of $K=0.37$ and $L_{inf}=149$ for females and $K=0.37$ and $L_{inf}=139$ for males. These growth estimates were obtained from captive sharks and may not be representative of growth rates exhibited by the wild population. Preliminary results portray much lower von Bertalanffy growth parameter estimates. Estimates for both sexes combined were: $L_{inf}=148$, $K=0.11$, and $t_0 = -3.67$. Available tag-recapture data support these estimates.

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Estuarine and coastal habitat use of Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) in the north-central Gulf of Mexico

Both the Atlantic and Gulf subspecies of *Acipenser oxyrinchus* are anadromous; however, in both forms, much less is known about marine compared to freshwater habitat use. We used sonic telemetry to investigate marine habitat use of Gulf Sturgeon natal to the Pascagoula and Pearl Rivers in Mississippi. Because adult and subadult fish do not feed while in fresh water, movement to marine feeding grounds is an essential part of their life cycle. Although timing is variable, sturgeon typically move from fresh to salt water during October and November in response to falling water temperature, changes in day-length, and spikes in river discharge. Between 1999 and 2004 we tagged 119 adult and subadult fish during their freshwater residency in the Pascagoula River. Over the five winter-spring field seasons, we located 48 different fish, some of them multiple times, for a total of 73 relocations. Of these, 23 locations, representing 18 individuals, were tagged in a companion study in the Pearl River. Most fish were located from November through March and 84% of the locations were in the region of the barrier islands bordering Mississippi Sound. Ninety-two percent of

fish located near the barrier islands were associated with passes. Gulf Sturgeon were in generally shallow (average 3.9 m; range 1.2-6.6 m) water. Benthic samples taken over three field seasons (2001-2004) indicated that substrata in these areas are typically clean, coarse sand and the macro-benthic fauna, indicative of potential prey, is dominated by lancelets, bivalve mollusks, brittle stars, polychaetes, and haustoriid amphipods.

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Influence of forest fragmentation on growth and survival of juvenile salamanders (*Ambystoma* spp.)

We compared demographic traits of postmetamorphic salamanders among old fields, forest interior, and edge habitats over two years. Recently metamorphosed spotted salamanders (*Ambystoma maculatum*) and marbled salamanders (*A. opacum*) were individually marked, added to terrestrial enclosures, and recaptured in pitfall traps. Proportion known alive in the fields was < 5% by the first fall and declined to zero for both species in the second year. High summertime temperatures, but not differences in soil moisture, probably contributed to the mortality of juveniles in field enclosures. In forested enclosures, significantly more marbled salamanders (mean 38.5%) and spotted salamanders (mean 16.7%) survived until the first fall and several individuals of each species attained sexual maturity. Mean proportion known alive was approximately two times higher in marbled salamanders than in spotted salamanders, perhaps due to an advantage of earlier metamorphosis in *A. opacum*. Our results indicate the first few months in the terrestrial environment is a critical period determining survival between metamorphosis and first reproduction. Juveniles that weighed more initially had greater chances of surviving this period. We found no evidence that proximity to forest edges incurred fitness costs in terms of growth or survival for juvenile ambystomatids. Because no juveniles survived to maturity in fields, breeding sites surrounded by non-forested habitat may be population sinks for these species.

***ROUNTREE, RODNEY A.; GOUDEY, CLIFF; EKSTROM, KEN; ANDERSON, KATIE**

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Determination of daily spawning patterns of haddock based on field recordings of vocal activity.

We have successfully recorded haddock spawning sounds in the Jeffreys Ledge-Stellwagen Bank region of the Gulf of Maine. *In situ* recordings of this type have

not previously been made in North American waters. To do this, we have developed novel underwater passive acoustic probes (hydrophones/recorders) for use cooperatively by commercial fishermen. The Acoustic Underwater Listening Stations (AULS) are deployed on the seabed much like passive fishing gear and continuously record ambient sounds for up to 60 h (at an 11 kHz sampling rate). During two field seasons, we have collected over 3,000 hours of acoustic recordings from 67 deployments within the Gulf of Maine, representing over 500 GB of data. The identifications of haddock sounds were made by comparing the waveforms and spectra of field recordings to that of known haddock calls recorded in published laboratory studies. Based on our preliminary analysis of underwater recordings in the Gulf of Maine, we have shown that we can count the number of haddock calls that occur in the vicinity of an AULS unit. This methodology has previously been used in the study of fish and has seen widespread use for frog studies for many years. Preliminary results from these on-going studies suggest that most haddock spawning activity occurs in the late afternoon and early evening. *In situ* data on vocal activity/spawning activity patterns of this type have never been documented before for haddock, or indeed for any other groundfish species from the important Gulf of Maine-Georges Bank fishing region. It provides important new data for fisheries managers that could better facilitate the protection of spawning aggregations.

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MARTINS, DAVID**

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The human predator: Influence of target species on catch in the Georges Bank Trawl Fishery

We collaborated with the New Bedford trawl fleet to collect catch from the Georges Bank groundfish fishery between November 2000 and August 2004. A major incentive for the project was to recognize the desire of the commercial fishing community to participate more directly in the management of the resource. Catch data were recorded from 7,911 trawl tows from 209 trips. A total sampling effort of 1,552 days at sea and 23,247 hours of trawling resulted in the capture of over 12 million lbs of fish, of which 8.7 million lbs were kept and 3.8 million lbs were discarded. The catch composition consisted of 51 species/species groups, with skates, monkfish, Atlantic cod, haddock and winter flounder predominant. Skate constitute the dominant discard species (80%) followed by spiny dogfish, barndoor skate, sea raven, and monkfish. Fourteen species or species groups were targeted by the fishermen, with multispecies groundfish, monkfish, Atlantic cod, winter flounder, monkfish, haddock and yellowtail accounting for 95% of the effort. The influence of target species on trawl catch is complex. Catch was typically dominated by the target species, except for several cases where the target was second to skate. Total combined species catch was greatest when targeting skates, and least when targeting redfish, witch flounder and American plaice. However, discard was greatest when targeting winter flounder, yellowtail and scallop. The greatest percent catch discard occurred when winter flounder, scallop, yellowtail and lobster were targeted, and least when monkfish, redfish, hake mix, or skate were targeted. Target species had a strong influence on catch per unit effort

(catch/tow duration). Often catch of target species tended to be unrelated to tow duration, while non-targeted species could exhibit positive, negative, or no relation to duration. These patterns were used to infer seasonal changes in distribution types of target species.

***ROW, JEFFREY R.; BLOUIN-DEMERS, GABRIEL**

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Thermal quality influences investment in thermoregulation, habitat use, and behaviour in milksnakes

Thermoregulation has costs and benefits and, therefore, the extent of thermoregulation should be adjusted to maximize the benefit to cost ratio. The central prediction of the cost-benefit model of thermoregulation is that ectotherms should invest less in thermoregulation when thermal quality is low. Recent comparative data suggest the opposite: lizards invest more in thermoregulation when thermal quality is low. Because the cost-benefit model was designed for intraspecific comparisons, however, we provided a more stringent test of the central prediction of the model with eastern milksnakes (*Lampropeltis triangulum*). Because behavioural thermoregulation is accomplished through habitat selection, we also investigated the link between thermoregulation, habitat use, and behaviour. During 2003-2004, we located 25 individuals 890 times and recorded their body temperature. Thermal quality was lower in the spring and fall than in the summer, and was also lower in forests than in open habitats. Milksnakes invested more in thermoregulation in the spring than in the summer and fall, and more in the forest than in open habitats, which was contrary to the central prediction of the cost-benefit model of thermoregulation. Milksnakes had a strong preference for open habitats in all seasons, which was likely to facilitate behavioural thermoregulation. The preference for open habitats was equally strong in all seasons and, therefore, the higher investment in thermoregulation was not a result of altered habitat use. Instead, milksnakes modified their behaviour and were seen basking more and moved less in the spring than in the summer. **SSAR SEIBERT ECOLOGY**

***ROWE, CHRISTOPHER L.; HOPKINS, WILLIAM A.; SALICE, CHRISTOPHER J.; PECHMANN, JOSEPH H. K.**

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Temporally- and spatially-disparate influences of anthropogenic stressors on amphibian populations: Models of effects of aquatic contaminants and terrestrial habitat reduction

Because of the complex life cycles exhibited by most extant amphibian species, amphibians may experience environmental stressors operating at temporally- and spatially-distinct scales. The relatively brief aquatic life stages of many

species limits the duration of exposure to conditions in aquatic habitats, and the spatially-limited nature of such habitats may provide exposures to stressors unique to the breeding site. On the other hand, long-lived adults dispersing into terrestrial habitats may experience landscape-scale disturbances operating over much longer periods of time. Focusing on the eastern narrowmouth toad (*Gastrophryne carolinensis*), we combined novel and existing data to construct matrix population models to examine potential influences of aquatic habitat contamination and reduced per capita availability of terrestrial habitat on projected population growth rates. Under conditions of low terrestrial habitat availability and contamination of the aquatic habitat, population growth rate was primarily influenced by survival through the first year (embryos, larvae, terrestrial metamorphs), followed by survival through year 2 (terrestrial juveniles). Under conditions of high terrestrial habitat availability and contaminated aquatic conditions, population growth rate was also primarily influenced by survival through the first year, however survival through ensuing years was relatively unimportant. When examined individually, aquatic contamination had a greater influence on population growth rate (33 % reduction) than did terrestrial habitat restrictions (19 % reduction). With respect to contaminants, larval survival had the greatest influence on population growth compared to reductions in hatching success and fecundity of females inhabiting the contaminated site. The combined influences of aquatic contamination and reduction in terrestrial habitat reduced projected population growth rates by 46 % compared to optimal conditions. Our study emphasizes the importance of considering multiple sources of stress operating at distinct temporal and spatial scales when attempting to identify potential correlates with amphibian population declines.

***ROWE, JOHN W.; CLARK, DAVID L.; RYAN, COLLEEN; PRICE, MICHAEL D.; TUCKER, JOHN K.**

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Substrate color-induced pigmentation patterns of integuments in midland painted turtles and red-eared slider turtles

We studied the degree of shell darkness (as measured by intensity values) in Midland painted turtles (*Chrysemys picta marginata*) residing in different habitats of the Beaver Island Archipelago by analysis of digital images and spectrometric techniques. Turtles from habitats with dark substrates (inland marshes and swamps) had carapaces that were darker when compared to turtles from habitats with light-colored sand and algae covered substrates (Lake Michigan harbors of Garden Island) that had lighter colored carapaces. There was no variation in intensity of plastrons among localities. To test whether the degree of shell darkness among populations might be a plastic response to variation in substrate darkness, we reared hatchling painted turtles and the closely related red-eared slider turtles (*Trachemys scripta elegans*) for 150 d on either black or white substrates under laboratory conditions. On the black substrate, carapaces and dorsal head skin darkened slightly in painted turtles although darkened substantially in slider turtles. On light backgrounds, carapaces and dorsal head skin lightened dramatically in painted turtles but less so in slider turtles.

Intensity of the plastron (in areas with little pigment) was unaffected by substrate color in either species. A subsequent experiment, where substrate treatments were reversed after turtles were reared for 80 d on either a black or white substrate, indicated that shell pigmentation is reversible.

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Scale of morphological variation in estuarine fish species

Organisms respond to heterogeneous environments, such as variation in resources, abiotic parameters, and threats of predation through adjusting their physiology, morphology, and/or behavior. Focusing on morphological variation, we examined the scale and pattern of intraspecific variation in estuarine fish between locations and between habitats for each of three species: spot (*Leiostomus xanthurus*), silver perch (*Bairdiella chrysoura*), and pinfish (*Lagodon rhomboides*). Spot and pinfish exhibited morphological variation at both spatial scales. There was no evidence of variation in silver perch. Patterns of phenotypic diversity between locations might represent plastic responses to site specific environmental processes. Observed morphological diversity between habitats was distinctive to species. Spot revealed relatively streamlined bodies in barren habitats while pinfish were characterized as relatively deep bodied. This suggests different ecomorphological solutions to similar environmental gradients; indicative of the characteristic evolutionary history of these distantly related taxa. We do not know if this phenotype-habitat association is due to phenotypic plasticity, habitat choice, or genetic differentiation. However, natural history of the two species and the scale of variation suggest plasticity or habitat choice as the major sources of variation. In any case, these results indicate that conserving phenotypic variation is tied to preserving habitat variation.

RUTHIG, GREGORY R.

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Interaction between the environment and the infectious disease *Saprolegnia* on amphibian egg-laying behavior

I studied the implications of the pathogen *Saprolegnia* on amphibian egg-laying behavior. *Saprolegnia* spp. is a ubiquitous aquatic Chromista (formally in the kingdom Fungi) that exists in nearly all freshwater systems. I found that several strains of *Saprolegnia* were pathogenic on the eggs of bullfrogs (*Rana catesbeiana*: Ranidae) and spring peepers (*Pseudacris crucifer*: Hylidae) in the southern Appalachian Mountains. I report how environmental factors, such as pH, dissolved oxygen, temperature, sun exposure, and the density of infective *Saprolegnia* propagules, influence the breeding behavior of adult bullfrogs and infection rates in their eggs. Southern leopard frogs (*Rana sphenoccephala*) at the Savannah River Site in South Carolina have developed a social structure that may allow them to minimize the transmission of *Saprolegnia* between egg masses

by altering the distribution of their eggs. In colder months, many mating pairs aggregate and lay large communal egg masses that provide insulation for the eggs from cold temperatures. In the summer, however, the same frogs mate in isolated pairs and lay their eggs in individual masses. Since *Saprolegnia* is best able to grow and produce infective propagules in warmer water, I have proposed that the frogs may alter their social behavior to limit disease transmission among their offspring. I performed field and laboratory experiments that manipulated temperature, the presence of *Saprolegnia* and the distribution of southern leopard frog eggs. The results from this work will shed light on the selective pressures that infectious diseases have had on amphibian behavior, and on the potential effects of infectious disease on amphibian populations in the face of global climate change.

RYAN, TRAVIS J.

Butler University, Department of Biological Sciences, Indianapolis, IN 46208, USA

Larval ecology of *Ambystoma texanum*: Experimental studies of hydroperiod, density, and growth

The Small-Mouthed Salamander (*Ambystoma texanum*) is one of the most common caudates throughout the Midwestern United States, breeding in temporary ponds. Like other pond-breeding amphibians, populations are at risk of local extinction due to alterations of the breeding habitat. Despite its wide distribution and high relative abundance, surprisingly little is known about the larval ecology of *A. texanum*. I conducted a mesocosm experiment to investigate the effects of hydroperiod (the length of time that a temporary wetland holds water) metamorphosis of *A. texanum*. I used hydroperiods of 50, 75, and 100 d, and a non-drying treatment as a control. Survival to the end of each hydroperiod was consistent among all groups, but no individuals completed metamorphosis in the 50-d treatment. The proportion of individuals completing metamorphosis increased with longer hydroperiods, as did the age at metamorphosis. The size at metamorphosis, however, was not affected by the length of the hydroperiod. I also report on another mesocosm experiment testing the effect of density on metamorphosis, and a laboratory experiment investigating the role of individual growth trajectories on metamorphosis. The goal of these studies is to develop a stronger understanding of the species' larval ecology to permit informed decisions in managing for the long-term persistence of *A. texanum* populations.

RYAN, TRAVIS J.; *CONNER, CHRISTOPHER A.; PETERMAN, BILL

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Spatial ecology of turtle populations within an urban landscape: Implications for conservation and habitat management

Our study focuses on the spatial ecology and seasonal habitat use of three aquatic turtles living in a man-made canal within a highly urbanized region of Indianapolis, IN, USA in order to understand the manner in which upland habitat use by humans shapes the activity, movement, and habitat selection of

these species. We used radio telemetry to follow 15 female *Graptemys geographica* (common map turtle), 10 male and 10 female *Trachemys scripta* (red-eared slider), and 12 male and 12 female *Chelydra serpentina* (snapping turtles). During the active season (between May-September) of 2002, we located 33 *G. geographica* and *T. scripta* individuals more than 900 times; during the 2003 field season we recorded more than 1700 locations of individuals of the three species. We determined the total range of activity, mean movement, and daily movement for each individual. We also analyzed turtle locations relative to the upland habitat types (commercial, residential, river, road, woodlot, and open) surrounding the canal. Our data show that all three species spend a disproportionate amount of time in woodland and commercial habitats and avoided the road-associated portions of the canal. We also located 21 of the *G. geographica* and *T. scripta* individuals during winter 2003 and the *C. serpentina* in the winter of 2004, and determined that an even greater proportion of individuals hibernated in woodland-bordered portions of the canal. Our results clearly indicate that turtle habitat selection is influenced by human activities; sound conservation and management of turtle populations in urban habitats will require the incorporation of spatial ecology and habitat use data.

***SABA, VINCENT S.; SANTIDRIÁN TOMILLO, PILAR; REINA, RICHARD D.; SPOTILA, JAMES R.; PALADINO, FRANK V.; MUSICK, JOHN A.; EVANS, DAVID A.**

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The El Niño Southern Oscillation: A biological clock for Eastern Pacific leatherback sea turtles

Our study examined the sensitivity of nesting Eastern Pacific leatherback turtles (*Dermochelys coriacea*) to environmental stochasticity at their potential foraging areas in the Eastern Tropical Pacific. We accomplished this by using sea surface temperature (SST), as measured by satellite, as an indicator of feeding conditions for leatherbacks nesting at Playa Grande, Las Baulas National Park, Costa Rica. We used 11 years of PIT tagging data to derive nesting remigration intervals for each nesting season up to 2003. We used SST anomalies from 4 El Niño Southern Oscillation (ENSO) regions along the Equatorial Pacific Ocean. We designed a log likelihood probability model to determine the relationship between the SST anomalies and leatherback remigration probabilities. Leatherback remigration intervals ranged from 2 to 7 years. When the SST anomalies were incorporated into the model, our estimate of the number of remigrants at Playa Grande from 1995 to 2003 fit the observed data at a significance level of $P \ll 0.0005$ when compared to the model's fit without the anomalies. We found that using the mean SST anomaly from ENSO 4 (150° W to 160° E) 25 months prior to each nesting season produced the best remigrant number fit ($= 89.81$). A shift from 1 °C to -1 °C in the ENSO 4 SST anomaly increased the leatherback remigration probabilities by 5 times. Cooler values of SST are indicative of highly productive La Niña events that follow warmer, less productive El Niño events. These SST shifts correspond with changes in the upwelling magnitude of cold, nutrient rich

water that may be regulating the biomass and distribution of gelatinous zooplankton, the primary food source for leatherbacks. Our results suggest that the ENSO 4 SST anomaly is currently the "best signal" for feeding conditions of nesting leatherbacks at Playa Grande. A time period of 25 months of SST prior to each nesting season represents the critical feeding period affecting each season's remigrants. This suggests that it takes at least 2 years for nesting females to build enough energy stores required for vitellogenesis. These results suggest that the remigration intervals of leatherbacks nesting at Playa Grande are highly dependent upon environmental conditions in the Equatorial Pacific Ocean.

***SABAJ, MARK H.; SALCEDO, NORMA J.; ORTEGA, HERNAN**

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Piscatorial highlights from the Peruvian leg of the Trans-Continental Catfish Expedition sponsored by the All Catfish Species Inventory

In July and August 2004, two separate international teams of ichthyologists traveled across central South America (between 5 and 16 degrees latitude) in a near Trans-Continental Expedition in search of new species of catfishes for the NSF funded All Catfish Species Inventory. Team Brasil (coordinated by Roberto E. Reis) began sampling in the upper Paraguai and followed a northwesterly course to the site on the Rio Acre where the borders of Bolivia, Brasil and Peru meet. Team Peru (coordinated by the co-authors of this talk) proceeded south from Lima along the Pacific Coast and cut across the Andes in a northeasterly direction to finish at the same point on the Rio Acre. Both expeditions successfully compiled large collections of fishes from poorly sampled regions. The Peruvian expedition focused on major Andean rivers and their smaller tributaries at elevations of 560 to 3999 meters in the Apurimac and Urubamba basins (Ucayali Drainage) and at elevations of 164 to 2665 meters in the Madre de Dios basin (Madeira Drainage). The Peruvian fieldwork yielded an estimated 15 to 20 undescribed species of siluriforms (i.e., Aspredinidae, Astroblepidae, Auchenipteridae, Doradidae, Heptapteridae, Loricariidae, Trichomycteridae) and other Neotropical fishes (e.g., *Creagrutus*). The preliminary results of the Peruvian expedition will be presented with comments on the biogeography of the region and photographs of the new or otherwise rarely seen fishes of southern Peru.

***SADINSKI, WALT; WILSON, MICHELLE; BOURASSA, SAM; MEYER, LEAH; ROTH, MARK; YAHN, JEREMIAH**

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Disparate effects of climate on amphibians

Extremes in temperature and precipitation can greatly reduce fitness in amphibians. Multiple years of such extremes could cause populations to decline via consistently reduced fitness among individuals. We observed different mechanisms by which extremes in climate can reduce the fitness of amphibians during studies in two very different ecological systems: alpine forests and meadows in Yosemite National Park and the floodplain of the upper Mississippi River. Yosemite toads (*Bufo canorus*) bred in shallow, ephemeral wetlands at high elevations (2800–3200 m) in Yosemite National Park; these wetlands often froze overnight, killing embryos, and dried before metamorphosis occurred, killing larvae. Additional embryos died via smothering by watermold (*Saprolegnia diclina*) that appeared to infect egg masses at higher rates when egg masses were exposed to ice and in association with predatory flatworms (*Turbellaria*). Mortality among embryos was as high as 100% in some egg masses. In general, we observed that mortality among embryos increased when minimal daily air temperatures decreased during 1997–2001. We observed completely different mechanisms by which climate can affect the fitness of amphibians in the floodplain of the upper Mississippi River, where at least 13 species of amphibians live. Snowmelt, precipitation, and land use on the upper landscape cause floods in this area that have increased in frequency and severity over the past 50 years. Floods can displace individual amphibians, distribute predators across the floodplain, and disrupt breeding. They also can distribute pesticides and other contaminants to breeding sites that are typically not connected to the river. During floods in 2004, concentrations of Triazines increased at breeding sites to levels that might cause abnormal development in exposed frogs. These contrasting mechanisms and effects demonstrate that we have much to consider when evaluating the risk that extremes in climate pose to populations of amphibians.

***SAGE, JOSEPH R.; KINGSBURY, BRUCE A.**

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Massasauga rattlesnake responses to a large scale habitat restoration project: Results from a spatial ecology and habitat utilization study.

The Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*) is a species in decline, and is legally protected in every state in which it occurs. Conservation measures have been initiated in many populations in order to facilitate the recovery of this species. Successful conservation of declining species relies on sound biological information as a guide for conservation strategy as well as effective monitoring to assess the impacts of management activities on local

populations. Over the past three years, we have been using radiotelemetry to study the spatial ecology and habitat utilization of a population of eastern massasaugas in southeastern Michigan. We draw upon the results of this study to assess the impact of a large scale habitat restoration project occurring on site. Active habitat management techniques are being used to convert a 27 hectare section of the study site from degraded old field habitats to native wetland and prairie communities. Although this activity has the potential to benefit rattlesnakes at this site in the long term, the intensive disturbance caused by this project may negatively impact snakes in the short term. Radiotelemetry results demonstrated that rattlesnakes typically avoided disturbed habitats, but these habitats were still important for some functions, such as migration and gestation for gravid female snakes. As a result, home ranges overlapped disturbed habitats extensively. Habitat analyses also indicated a higher than expected utilization of disturbed habitats. Our observations suggest that while habitat restoration activities have influenced snake movements and habitat utilization, the short term impacts on this population have been relatively benign. **SSAR SEIBERT CONSERVATION**

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Observations on the hibernation ecology of the Eastern Massasauga Rattlesnake in southeastern Michigan

The hibernation requirements of the Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*) remains one of the most poorly studied aspects of the species biology. This is particularly troubling, given that suitable hibernation sites seem to be limited across the landscape, and massasauga populations may be especially vulnerable to alterations in those areas. In order to fill this gap in our knowledge, we have initiated a study of the hibernation ecology of the eastern massasauga, focusing on a population of snakes in southeastern Michigan, and present here preliminary observations from this work. Radio telemetry was used to locate hibernacula over a period from 2002 to 2005. Hibernacula were located along wetland edges, primarily in open canopied habitats, and were typically found outside or along the edge of snake summer activity ranges. Snakes at this site hibernated within crayfish burrows. During winter months, a fiberoptic scope was used to monitor the position of massasaugas, their behavior, and relationship to groundwater within the burrows. In addition to the fiberscope, groundwater wells were installed near burrows and were used to monitor groundwater levels and temperatures throughout the winter. Water table depths ranged from 0-61 cm, with an average of approximately 27 cm. Snake depths ranged from 0-85 cm, with an average of approximately 43 cm. Snakes were found completely submerged on most occasions, with an average submergence depth of 14 cm. Snakes were observed to share burrows with a variety of herpetofauna, including other *Sistrurus*, *Thamnophis sirtalis*, *Thamnophis sauritus*, *Coluber constrictor*, *Rana pipiens*, and *Pseudacris triseriata*. The conservation implication of our findings will be discussed.

***SAITOH, KENJI; MIYA, MASAKI; HANZAWA, NAOTO;
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Relationships among major groups of cypriniform fishes based on mitochondrial genomic data

Cypriniformes comprise the most diverged primary freshwater fish group with five (or six) families, 16 subfamilies, about 281 genera, and 3,344 species (data calculated from FishBase; <http://www.fishbase.org>). This time we are going to present phylogenetic relationships among 50 cypriniform species representing five (or six) families and 15 subfamilies to test monophyly of the major groups and their interrelationships. We have sequenced the complete mitochondrial genomes from 43 cypriniform fishes (26 from cyprinids, four from balitorids, three from cobitids, two from botids, seven from catostomids and a gyриноcheilid fish). We conduct a Bayesian and a maximum likelihood analyses of phylogenetic relationships among newly determined 43 mitochondrial genomes together with 13 published ostariophysan data. The GTR + gamma + partitioned analyses of more than 10,000 nucleotide sites are now ongoing, and up to now we have recovered monophyly of Cyprinidae, Cobitidae + Balitoridae and Catostomidae, respectively. We have also recognized paraphyly of the conventional Cobitidae (Cobitinae and Botinae) relative to the monophyletic Balitoridae (Balitorinae + Nemacheilinae), and thus erection of Botidae has a phylogenetic basis. Use of this large nucleotide sequence dataset has merits not only for resolving branching pattern of higher order taxa but also for finding novel assemblages (mostly geographic) that are different from conventional classification. It is useful as well to find out closest relatives of species or group of unclear phylogenetic position such as *Pelecus*, *Vaillantella*, bitterlings, etc.

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Patterns of fish diversity along an elevational gradient in the Perené River Basin, central Peru

The Perené River in central Peru is located between latitudes 10°30'–11°30'S and longitudes 74°–75°30'W. It is a tributary of the upper Ucayali River, which drains into the Amazon River. It runs down the eastern slope of the Andes in a West to East direction, for approximately 140 km to the confluence with the Ene River and ranges from above 260 to 750 m elevation. Material collected from the Perené River Basin between 260 to 2000 m, from 1953 through 2003, deposited in the Ichthyology Collection of the Museo de Historia Natural, Universidad Mayor de San Marcos (MUSM) was studied. Forty seven fish species have been identified from the Perené River and tributaries. The family Characidae is the best represented in number of species (47% of the total number of species), followed by the families Loricariidae and Pimelodidae with 19% and 13% of the species,

respectively. Species restricted to elevations above 700 m are *Creagrutus ouranonastes*, *Chaetostoma lobarhynchus*, and *Astroblepus sabalo*. Species restricted to elevations below 600 m are *Astyanax fasciatus*, *Attonittus irisae*, *Hoplias malabaricus*, *Steindachnerina guentheri*, *Chaetostoma lineopunctatum*, *Poecilia reticulata*, and *Synbranchus marmoratum*. Although expected, cichlids were not found and only one exotic species (*Poecilia reticulata*) was collected. The fish fauna of the Perené River basin exhibits high richness when compared to other basins at similar elevations, but this can be an artifact of lack of intensive inventory works in this kind of environment. **STOYE GENERAL ICHTHYOLOGY**

SALCEDO, NORMA J.

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Taxonomic accuracy and the potential distribution of the catfish genus *Chaetostoma* (Siluriformes: Loricariidae)

Museum collections represent a vast source of information for conservation purposes. Accurate identification of the species collected and geographical reference of the collection sites, together with GIS analysis tools, can be used to determine potential distribution areas of target species. The need of revisionary works for the accurate identification of museum specimens that can be used for determining actual and potential distribution areas is evaluated for the catfish genus *Chaetostoma*. Tropical Andes have been pointed out as one conservation hotspot in the world. Not many fish species are distributed in the Tropical Andes but *Chaetostoma* species are distributed in fast flowing rivers on the eastern slope of the Andes. The genus *Chaetostoma* is distinctive and considered to be easily distinguished from other genera. According to ongoing revisionary work, three species described from Peruvian material should be excluded from the genus *Chaetostoma*. The effect of this exclusion on the actual and potential distribution of *Chaetostoma* is evaluated in relation to mean temperature, solar radiation, precipitation, flow direction, elevation, and aspect. The extent of the geographical distribution of the *Chaetostoma* is restricted by elevation, and the actual and potential distributions are reduced following removal of the excluded species. Because *Chaetostoma* species are easily recognized they may be valuable indicators of the distribution of aquatic communities in need of protection in the Tropical Andes. **STORER ICHTHYOLOGY**

***SAMARCO, THOMAS J.; TURINGAN, RALPH G.**

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Variation in feeding functional morphology and prey capture performance between wild and hatchery Red Drum, *Sciaenops ocellatus*

Populations that experience different environmental conditions may exhibit variation in morphological, physiological, biochemical, and behavioral characteristics. In an attempt to explore the effects of rearing environments on prey capture performance and functional morphology of the feeding mechanism

in red drum, *Sciaenops ocellatus*, prey capture kinematics and feeding-relevant morphometrics were compared between wild-caught and hatchery-reared juvenile red drum. Using high-speed videography, prey capture events were recorded and analyzed for maximum cranial excursions and timing variables. Then in a series of overlapping size fish from both populations, several morphological and biomechanical measurements were taken including: gape height/width, upper/lower jaw length, head height/width, standard/total length, adductor mandibulae complex, sternohyoideus muscle, and mechanical advantage of the lower jaw. Wild-caught red drum when feeding on mosquitofish, *Gambusia holbrooki*, had larger cranial excursions (maximum gape, premaxillary protrusion, and hyoid depression) relative to hatchery-reared conspecifics. However, time to reach maximum cranial excursions did not vary between hatchery and wild red drum. These results reveal that hatchery-reared red drum have different prey capture kinematics relative to their wild conspecifics during initial exposure to natural prey in their environment. The inefficiency of hatchery-reared red drum to capture wild prey upon release into the natural environment may have important implications for their use in stock-enhancement programs. Further studies designed to pre-adapt hatchery-reared red drum to feed on prey organisms in the wild have to be conducted in order to improve the prey capture performance of hatchery-reared fish before they are released into the natural environment.

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Do predation risks influence the duration of spawning rushes in reef fishes?

Predation risks can influence spawning behaviors of coral reef fishes, which experience high mortalities when performing spawning rushes. Attacks by predatory fish are most commonly directed to diurnal group spawning species. The swimming speed of spawning fishes is hypothesized to be influenced by varying risks of predation. The duration of spawning ascents was measured for 13 reef fish species at Johnston Atoll (central Pacific) through analysis of underwater video footage. As originally expected, fishes that spawned in pairs were slower than group spawning species. The duration of spawning ascents neither varied between fishes spawning at daytime and dusk, nor between group spawning species with and without specific anti-predatory morphological adaptations. These results indicate that relative predation risks may not be such an important factor as previously believed, and leads us to hypothesize that female mate choice may strongly influence the duration of spawning ascents in group spawning fishes.

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Genetic structure of batoid fish populations from the Gulf of California and the Pacific Baja California coasts

Batoid fishes play an important roles in the population control of the other marine species; as links in the flow of energy and matter of the marine ecosystem; and as fishing resources in the coasts of the Mexican Pacific. The Pacific coast of Baja California and the Gulf of California harbor a rich and diverse assemblage of batoid fauna, because of its recent and geologically active history during the last 6 million years, this region is of particular interest to study the effect of dispersal and vicariant events and possible processes of incipient speciation in marine and terrestrial biotas. The aim of this work is to examine the relationship between the levels of diversity and genetic structure with the mobility and fecundity in five species of batoid fishes (*Myliobatis californica*, *Rhinobatos productus*, *Rhinoptera steindachneri*, *Narcine entemedor* y *Gymnura marmorata*) collected from the Gulf of California and the Pacific Coast of Baja California. PCR-RFLPs of the mitochondrial NADH2 gene revealed variable levels of haplotype and nucleotide diversities ranging from 0 to 0.51 and 0 to 3.41%, respectively. No relationship was found between levels of fecundity and genetic diversity of the species. The degree of differentiation and genetic isolation between populations assessed with AMOVA, varied from none to extremely high levels ($0 < ST < 0.94$). There was no relation between species mobility and levels of the genetic structure. No general phylogeographic concordance was found between Gulf and Pacific populations but at least two species showed significant Pacific/Gulf differentiation.

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The effects of suction generation on prey capture in bamboo sharks

Suction feeding is the most common means of prey capture in fishes. In contrast to the large body of literature on suction feeding in teleosts, sharks have received little attention. No studies have yet explored how suction pressures generated in the mouth cavity during inflow of water translate to pressure changes in front of the mouth at the position of the prey. Furthermore, we have no idea of how predator size affects this relationship. Whitespotted bamboo sharks, *Chiloscyllium plagiosum*, are strong suction feeders and feed readily while resting on the substrate. Suction pressure at the position of the prey was recorded at specific locations in front of the mouth of three different size classes of shark. Predator and prey positions were recorded simultaneously using high speed video. Maximum drop in pressure at the prey was achieved quickly during suction feeding and on average was smaller in magnitude than in the mouth cavity. Mean suction pressure attenuates rapidly with distance from the front of the mouth. However, a drop in pressure, and therefore water velocity, is still evident at much greater distances than that reported for teleosts using other techniques. The magnitude and duration of suction pressure scales positively with predator

size. Interestingly, the mean pressures generated at the prey do not vary significantly when the pressure transducer is positioned in an arc from a line directly in front of the mouth indicating that the water inflow into the mouth is uniform and not anteriorly directed. Thus, the angular position of the prey relative to the front of the mouth will have a minimal impact on feeding success.

***SANTOS, JUAN C.; COLOMA, LUIS A.; CALDWELL, JANALEE P.; SUMMERS, KYLE; CANNATELLA, DAVID C.**

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Biogeography of the poison frogs (Anura: Dendrobatidae)

Poison frogs (Dendrobatidae) form an endemic Neotropical clade, and their current distribution extends from southern Nicaragua to Brazil, including the Guyana shield, Amazon Basin, Chocoan lowlands and elevation below 4000 m in the northern and central Andean Cordilleras. Using an extensive phylogeny (250 samples), we have inferred the patterns of dispersal and vicariance. We found multiple and alternative patterns of dispersal into the Amazon Basin from the surrounding areas such as the Andes, Central America, Guyana shield and Chocoan lowlands. The Amazon Basin has been a recipient of independent dispersals, from all dendrobatid lineages, which then radiated within the region but have not dispersed elsewhere. We also found at least two dispersals from the eastern side of the Andes to the Chocoan lowlands, suggesting a dendrobatid fauna exchange between both sides of the northern and central Andes. This supports the presence of an ancient portal through the Andes (the Marañon Gate). Our results indicate that biological diversity within the Amazon Basin can be understood from a broader geographical scale including all areas of the Neotropics.

***SANTOS, SIMONE H. D.; STEFANI, MÁRCIO N.; DUNÇAN, WALLICE L. P.; COSTA, OSCAR T.; ARAÚJO, MARIA LÚCIA G.**

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Macroscopic and hematologic analysis of lesions caused by *Potamotrygon* cf. *histrrix* in *Oryctolagus cuniculus*

Accidents caused by freshwater stingrays species are very common in Amazonian region, especially among riverine people who use Amazon River system as fishery or recreational purpose. In North of Brazil, injuries caused by stingray envenomations represent a health public problem. In a way to understand the clinical aspect of injury, an experimental study is being conducted to evaluate the evolution of macroscopic and hematologic aspects using as model organism, 12 rabbits of *Oryctolagus cuniculus* species (06 for control group and 06 for test group) and 06 individuals of freshwater stingray *Potamotrygon* cf. *histrrix*. Each rabbit for test group was sedated and a lesion was

produced by sting penetration in subcutaneous tissue from femoral region. Each rabbit for control group test was sedated and a unique aluminum stinger produced a lesion. After 24 hours of injury in test group, there was a progressive local erythema following by ulceration and necrosis; in one animal, gangrene was observed. Control group exhibited local erythema after 24 hours, followed by healing until the fourth day. Hematologic parameters were taken just before the lesion and 24 hours after lesion has been made. The results have shown that both groups exhibit the same tendency on values of hematocrit, hemoglobin concentration and RBC. Nevertheless the leucocytes exhibited significant difference between the groups. In control group, an increasing of basophils and neutrophils was observed. In test group the more significant increase were in number of eosinophils cells. Our results corroborate preview paper about marine stingrays envenomation, and suggest a particular inflammatory answer to the stingray lesion.

***SANTOS-BARRERA, GEORGINA; PACHECO JESUS; CHAOS, ALVARO; CEBALLOS, GERARDO**

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Conservation of amphibians and reptiles of Mexico: The role of the natural protected areas

Natural protected areas (NPAs) have been proposed to protect the flora and fauna from selected ecosystems and endangered species. The relevance of these areas for the protection of vulnerable and threatened species of vertebrates has been just recently evaluated in Mexico. Partial results indicate that their efficiency for vertebrate fauna is low. In this study, we analyzed the role of 35 NPAs towards the protection of Mexican amphibians and reptiles. This is a relevant issue because about 62% and 60% of the Mexican species of amphibians and reptiles, respectively, are endemic to Mexico. Moreover, more than 50% of Mexican amphibians have restricted ranges. Our results reveal that only 38% of the Mexican amphibians and 60% of the reptiles have protected populations. In the case of endangered or threatened species, only 29% of the amphibians and 46% of the reptiles in these categories are currently protected. This can be interpreted as a weakness in the NPAs system of Mexico. Our analysis shows that the richest protected area in Mexico is the Biosphere Reserve of Los Tuxtlas in southern Mexico, followed by the Sierra Gorda de Queretaro, the Islands in the Sea of Cortez, Baja California, Tehuacan-Cuicatlan, Chamela-Cuixmala, and the Canyon of Santa Elena. We estimate that at least other 28 NPAs are required to cover 80% of the Mexican herpetofauna. It is clear that better strategies for conservation can be chosen if quantitative methods are used to select and propose new protected areas in order to guarantee the preservation of the Mexican vertebrate fauna.

***SAPORITO, RALPH A.; DONNELLY, MAUREEN A.**

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Geographic and temporal variation in alkaloid chemical defense of the dendrobatid frog, *Dendrobates pumilio*

An alkaloid chemical defense has been well documented among tropical anurans worldwide, namely the brightly colored dendrobatids of Central and South America, mantellids of Madagascar, certain bufonids of South America, and several myobatrachids of Australia. Currently, more than 800 lipophilic alkaloids, representing at least 24 different structural classes have been identified in poison frogs. Unlike other chemical defenses in anurans, the presence of lipophilic alkaloids in poison frogs appears to be derived from a variable diet of alkaloid-containing arthropods, including ants, millipedes, and beetles. Alkaloid profiles (a measure of the type, amount, and number of alkaloids) of poison frogs are known to vary spatially and temporally, suggesting that differences in the availability of alkaloid-containing arthropods are the primary determinate of alkaloid profiles in poison frogs. Alkaloid profiles of the dendrobatid frog, *Dendrobates pumilio*, have been well studied over the past few decades, both geographically and temporally. In this study, we examine population-level alkaloid profiles in *D. pumilio* from multiple geographic locations throughout Costa Rica and Panama, many of which have been sampled repeatedly through time. Using non-metric multidimensional scaling (nMDS) for graphical visualization and analysis of similarity (ANOSIM) for statistical significance, alkaloid profiles of *D. pumilio* populations are shown to vary considerably with geographic location. In addition, alkaloid profiles created for populations of *D. pumilio* that were sampled repeatedly through time are also shown to differ considerably. The results of this study support the hypothesis that alkaloid profile variation in poison frogs is the result of differences in the availability of alkaloid-containing arthropod prey items over both geographic and temporal scales.

***SASA, MAHMOOD; WASKO, DENNIS K.; PINEDA, WILLY**

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The effect of snake presence on rodent foraging behavior

Predators not only have strong direct effects on the composition, behavior, and demography of their prey populations, but that they may also have indirect effects on entire communities. We designed several experiments to address the hypothesis that the pitviper *Bothrops asper*, a common predator in Middle American rain forest, regulate the habitat usage and/or foraging behavior of small seed-feeding rodents, which may have the cascade effect of mediating seed-predation rate. Each experiment was conducted in several species of wild caught Costa Rican rodents. We evaluate whether rodents avoid snakes based on either visual or olfactory cues in experimental choice arenas. We also tested the effect of snake presence on seed removal rates in the field, as an indirect

assessment of the role of this predator in the foraging behavior of its prey. Preliminary results suggest that both habitat selection and foraging effort of Costa Rican rodents are unaffected by the presence of *B. asper*. This contrasts with several other published studies addressing snake-rodent relationships; however, further studies and analyses may elucidate these trends.

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A captive study to determine the kinetics of $\Delta^{13}\text{C}$ and $\Delta^{15}\text{N}$ in corn snakes (*Pantherophis gutatta*)

Stable isotopes (SIs) of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) are commonly used to assess the feeding ecology and diet choices of organisms, although rarely for snakes or reptiles. This method is dependent on a number of assumptions of conservation or enrichment of the isotopes (i.e., the rate of change of isotope between prey and predator), which have rarely been tested and never in snakes. In order to understand the kinetics of SIs in snakes, we conducted a captive, controlled-diet study using 75 corn snakes (*Pantherophis gutatta*). Snakes were divided into two groups and force-fed earthworms (*Eisenia foetida*) at 10% body weight every three days that had either a low (control) $\delta^{13}\text{C}$ (~ -15%) and $\delta^{15}\text{N}$ (~ 8%) signature (for 144 days) or high (treatment) $\delta^{13}\text{C}$ (~ -50%) and $\delta^{15}\text{N}$ (~ 250%) signature (for 72 days followed by control food for 72 days). Three snakes were sampled (muscle, blood, and liver) from each treatment group on days 0, 9, 18, 36, 72, 81, 90, 108, and 144 and samples were analyzed for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$. The rate of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ change in the treatment group was greatest in liver, followed by blood and muscle. There were also significant differences in the rate of change depending on whether the diet switch was from a low to high or a high to low SI diet. Further, the rate of change in SIs suggest that upon a switch to a new diet the SI values in snakes may take > 100 to 500 days to come to equilibrium with the new diet. These results suggest caution when interpreting SI results from field caught snakes, particularly for species that have a varied diet, but demonstrate the potential utility of SIs if kinetics are understood.

***SAVITZKY, BARBARA; SPONTAK, DANA; DRAWDY, AURORA; BREEDEN, STEPHANIE**

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Red-backed Salamanders (*Plethodon cinereus*) in an urban preserve in the coastal plain of Virginia

The Red-backed Salamander (*Plethodon cinereus*) is a widespread and well-studied species in forests of the eastern United States, but little information is available concerning populations on the Coastal Plain. We have studied a population in an urban preserve, Mariner's Museum Park in Newport News, VA, since 2000. Although *P. cinereus* is the only species of terrestrial salamander

found in the preserve, densities are two orders of magnitude lower than those reported for populations the mountains of Virginia. Salamanders were found under leaf litter, small logs or pieces of bark from approximately October 15–May 15. Of 190 individuals captured, 24 were the red-striped morph and 167 were the leadbacked morph. Determination of sex was based on the condition of the nasolabial grooves, cloaca, and mental gland and/or the presence of visible ova. The smallest identifiable females were 26 mm SVL and the smallest males were 35 mm SVL. The largest individuals found were females, but the sexes do not differ statistically in mean SVL, tail length, or mass. The two color morphs do not differ significantly in size.

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Effects of variable and stable thermal regimes on growth, thermal tolerance and thermal preference of zebrafish

To evaluate the effect of stable (constant) versus variable (diel cycle) thermal regimes on the thermal biology of adult zebrafish (*Danio rerio*), we reared common-stock zebrafish from fertilization to adult in different thermal regimes and compared their growth rates, thermal preference, thermal tolerance, and heat-shock protein (hsp) levels. To control for acclimation effects, some adult fish were acclimated to either a stable or variable regime for two weeks prior to measuring tolerance or hsp levels. We found significant effects of rearing and acclimation regime on tolerance. Fish reared in variable environments had a lower tolerance and had higher levels of hsps than those from constant environments. Fish reared in the variable environment also had stronger diel shifts in thermal tolerance and a significant a diel shift in thermal preference compared to fish reared in constant environments.

SCHAEFER, JUSTIN T.

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Structural properties of calcification in batoid elasmobranch cartilage

As in all elasmobranchs, the cartilage skeleton of batoids functions as a stiff ultrastructure for muscle actuation during swimming. However, elastic cartilage is a suboptimal skeletal material, and must therefore be stiffened for efficient force transmission. Batoid swimming styles range from oscillatory (flapping) to undulatory (wiggling). These different locomotor modes place different stresses on the wing skeleton during motion. Because of this, we might expect that morphological adaptation would occur, maximizing the efficiency of the musculoskeletal swimming apparatus for each particular style. We have found several morphological differences, occurring at many different scales that appear

to stiffen the skeleton in areas specific to swimming style. At the smallest scale, the calcification patterns of the individual skeletal elements (radials) of the wing vary between a sheath of calcified plates (crustal calcification) in oscillatory swimmers to dorsal and ventral struts (catenated calcification) in undulatory swimmers. To explore the structural contributions of calcification style to the stiffness of the skeleton, we measured the stiffness of radials and joints from two species of batoids, one oscillator and one undulator. We hypothesized that crustally calcified radials of the oscillator would be stiffer than the catenated radials of the undulator. We further hypothesized that the joints between the radials would be a great deal more flexible than the radials themselves. Preliminary results show that crustal calcification is on average two orders of magnitude stiffer than catenated calcification, while the joints are on average nine orders of magnitude more flexible than the radials. This confirms that nearly all of the sometimes considerable bending of the batoid wing is occurring in the inter-radial joints. It also implies that the skeletons of oscillatory rays may be subjected to much greater stresses than those of the undulatory species. **AES CARRIER**

SCHAEFER, SCOTT A.

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Perspectives on the systematics of the African Alestidae (Characiformes)

The characiform family Alestidae comprises approximately 110 species of small to moderate-sized freshwater fishes widely distributed throughout much of sub-Saharan tropical Africa. Systematic studies on alestids have lagged behind that of Neotropical characiforms and have not progressed much beyond the 1967 classification established by Max Poll. Results from recent morphological and molecular studies highlight uncertainty regarding relationships of Alestidae among characiform fishes, the taxonomic status of subgroups within the family, and the utility of traditional morphological characters for establishing the monophyly and diagnosis of alestid genera and species. Problems regarding the classification of genera assigned to the patently non-monophyletic tribe Petersiini, the so-called dwarf alestids, are reviewed in light of new discoveries from recent molecular and morphological studies and recent new collections that suggest additional undescribed species diversity and highlight priorities for future research.

SCHAFFER, CHUCK

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The evolution of chelonian images: A historical perspective.

The oldest surviving chelonian images are represented in rock art and durable utilitarian objects such as weights and pallettes. However, the portable nature of paper makes it an ideal medium for zoological illustration with the earliest examples found dating from 800 years ago. Manuscripts from de Cantimpré 1240 *Liber de natura rerum*, van Maerlant 1350 *Der Naturen Bloeme*, and Candadu 1460 *De animantium naturis* provide the basis for subsequent examples of this

art. Illustration has always played an important role in biological investigation, sometimes serving as type specimens, as Schoepf's *Malaclemys (Testudo) terrapin* is that species' neotype. From cave art onward, it is an art form with styles and techniques undergoing evolutionary phases, from hand-written, hand-illustrated manuscripts to printed woodcuts, copper and later steel engravings. Hand-coloring progressed to chromolithography. Although images were often exaggerated or enhanced (Jonston, 1660), and did not always document scientific fact, interpretation of organisms was equally important (Dapper, 1673). Early images sought appeal with symmetrical unrealistic poses (Seba, 1735) and contexts. Peer pressure dictated particular designs as religious mores provoked stylized models. Content was also determined by what the intended audience might find of interest. Primarily avian artists, Catesby (1743), Audubon (1840), and Edwards (1751), all illustrated turtles. And not all early works were inaccurate (Aldrovandi, 1639; Caldesi, 1687), but the 1800s was a turning point in zoological illustration. The scientific method's influence was coupled with vivid realism and beautiful hand-coloring (Saint-Hilaire, 1809; Anderson, 1878; Gunther, 1885). Images were widely plagiarized (Commelin, 1645) with detail deteriorating in subsequent appearances or drawn from descriptions rather than living specimens (deBry, 1595; 1601), giving credence to inaccuracies, myths and errors. The late 1800s saw more works written for public appeal in the popular natural histories of Wood, Brehm, and Kingsley. The process continues today.

STOYE GENETICS, DEVELOPMENT & MORPHOLOGY

SCHAFFER, RICK; *SCHAFFER, CHUCK

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Activity levels of the Asian Giant Tortoise (*Manouria emys*): A comparison by cohort and photoperiod

Manouria emys is native to Southeast Asia from the Indonesian Archipelago north to Assam, India with *M. e. emys* south of the Thai-Malay border and *M. e. phayrei* to the North. They are found in a montane habitat of primary and secondary forest, but not in cleared land or plantations due to their need for high humidity. It has been extremely poorly understood since its description by Schlegel and Muller (1844) despite a variety of unique behaviors and characteristics including nest material modification, construction and guarding of nest mounds. It is the fourth largest worldwide of extant terrestrial genera, largest in Southeast Asia, and has the largest single clutches. Little is known about this species ex-situ behavior, and even less about their in-situ activity with only 12 ex-situ and two in-situ studies. Most other literature generally restates previous works, often with inaccurate information such as crepuscular activity, which this study contraindicates. With this lack of behavioral data, more studies need to be conducted to better understand their captive management, which is necessary to ensure the survival of this CITES appendix II listed species. This study of 19 *M. emys* of six age groups and both subspecies was initiated to gather more specific data and determine general characteristics of behavior, specifically activity. Tortoises were observed in natural, highly-shaded settings. Data collection was performed daily over 16 hourly intervals with activity levels evaluated at seven levels representing activity from complete rest (0-buried) to highly energetic (6-eating/drinking/mating). Data analysis suggested a roughly unimodal daily

activity pattern beginning one hour pre-dawn and continuing until five to six hours later when maximum levels were recorded. Activity dropped steadily until just after dusk. Observations also indicate a higher activity value for older larger animals which is likely related to body size.

***SCALES, JEFFREY A.; BUTLER, MARGUERITE**

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Locomotion during pregnancy in *Iguana iguana*

Many studies of locomotion in lizards have focused on steady speed running. However, most lizards likely use intermittent locomotion in natural settings, in which case acceleration and deceleration may be more ecologically relevant than steady state locomotion. The effect of pregnancy on the performance of lizards has also received little attention. Yet, reduced locomotor capacity is considered a cost of reproduction, and females must contend with pregnancy annually. In this study we compare the power production and kinematics of hind and fore limbs during acceleration in gravid and post-gravid *Iguana iguana*. **SSAR SEIBERT MORPHOLOGY & PHYSIOLOGY**

***SCHANK, CANDRA M.M.; SCHULTE-HOSTEDDE, ALBRECHT I.**

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Condition dependence of sexually dimorphic traits in the male green frog (*Rana clamitans*)

Secondary sex characteristics can give individuals competitive advantages over rivals in courtship, without being directly involved in copulation. These traits are sexually dimorphic and are thought to be costly to the individual when their expression becomes exaggerated. Because investment in these traits can be costly, it is predicted that the size of dimorphic traits is related to body condition. Male green frogs (*Rana clamitans*) have several secondary sex characteristics that are dimorphic including an enlarged tympanum, enlarged forelimbs, and a more yellow throat when compared to female green frogs. I tested the prediction that these dimorphic traits are condition dependent. I sampled male green frogs during the breeding season of 2004. Upon capture, individuals were weighed, and a series of variables were measured. Tympanum diameter, snout-urostyle length, measurements of the forelimb, and the degree of yellow on the throat were recorded. To estimate condition, I used body mass corrected for body size (snout-urostyle length). Males with relatively large forelimbs were in better condition than males with smaller forelimbs. Males with a pale yellow colouration on their throat were in poorer condition than males with a deeper yellow. Tympanum diameter was only weakly correlated with condition. These results suggest that some dimorphic traits are costly to produce in male green frogs; however their effects on mating success remain to be explored.

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Population and conservation genetics of the Gopher Tortoise (*Gopherus polyphemus*)

The gopher tortoise (*Gopherus polyphemus*) is an important member of the sandhill, longleaf pine, and scrub ecosystems in the southeastern United States. Even though it is currently protected throughout its range, tortoise population sizes continue to decline. We assessed genetic diversity at nine microsatellite loci in 300 individuals from 21 locations throughout Florida and southern Georgia. Tortoise populations are clearly subdivided into at least eight genetic assemblages with an $F_{ST} = 0.24 \pm 0.11$. Furthermore, we found indications of anthropogenic effects in the form of genetic bottlenecks in five populations and putative admixture in four. From these data, we recommend that the populations be managed to maintain existing genetic structure without further isolation of populations, and to establish a holistic database to include genetic and demographic information useful for relocation and management purposes.

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Amphibian lipid levels at metamorphosis correlate to post-metamorphic terrestrial survival

In organisms that have complex life cycles, a variety of factors in the larval environment may affect both larval and adult traits related to fitness. For amphibians, the transition between the larval aquatic environment and the postmetamorphic terrestrial environment may be a period of high mortality, particularly for juveniles in the months immediately following metamorphosis. The compartments into which an aquatic larva apportions its assimilated energy stores may influence its success during this critical period. We examined variation in total lipid levels among years ($N=7$) and sites ($N=4$) in recently metamorphosed individuals of two pond-breeding salamander species, with limited additional data for one anuran species. Both absolute and percent total lipid levels were highly correlated with body size; i.e., larger salamanders apportioned a higher percentage of their total body mass in lipids. Percent lipids in metamorphs ranged from 1.9 to 23.8% of total body dry mass. The two salamander species differed in their lipid allocation patterns, with marbled salamanders (*Ambystoma opacum*) apportioning a higher percentage of total lipid reserves into fat bodies than the congeneric mole salamander, *A. talpoideum*. For 16 cohorts of salamander metamorphs, we have mark-recapture data from drift fences that encircle the breeding ponds; these data were used to estimate the proportion of postmetamorphic animals that survived to breed during the first four years following metamorphosis. Percent lipids at metamorphosis was positively correlated ($P < 0.05$) with adult survivorship in both species. We suggest that lipid stores at metamorphosis may be vital to juvenile survival in the months following the transition to the terrestrial habitat. Species differences in lipid allocation patterns may also be related to variation in fitness-related traits

such as age at maturity.

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Adaptive regulation of digestive performance by boas and pythons

An adaptive response employed by sit-and-wait foraging, infrequently-feeding snakes to reduce energy expenditure between meals involves the downregulation of their gastrointestinal tract upon the completion of digestion. Feeding is then consequently met with a rapid upregulation of gut function that includes a large production of gastric acid, growth of the small intestine, and activation of intestinal nutrient enzymes and transporters. This wide regulation of digestive performance with feeding and fasting is exemplified by species of boas and pythons that feed infrequently in the wild. We have found for the boids, *Boa constrictor* and *Lichanura trivirgata*, and the pythonids, *Python molurus*, *P. sebae*, and *P. reticulatus*, that feeding generates an 8 to 19-fold increase in the small intestine's capacity to transport nutrients. This dramatic postfeeding increase in intestinal performance is a function of a 2-fold increase in small intestinal mass and 4 to 10-fold increases in mass-specific rates of nutrient uptake. Upon the completion of digestion, the intestines of these snakes are downregulated in mass and function. In contrast, frequently-feeding snakes species (family Colubridae) do not significantly downregulate their guts with fasting and thereby exhibit modest regulatory responses to digesting, increasing intestinal uptake capacity by only 2-fold. For boas and pythons, the fasting-related reduction in gut performance would contribute to reducing their metabolic rate and thus daily energy expenditure. Such a response may partly explain why boas and pythons possess significantly lower standard metabolic rates than frequently-feeding colubrid snakes.

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The Fred Berry fish atlas

This project is a preliminary compilation of photographs and collection data amassed by Frederick H. Berry (1927-2001). When completed, the project will include a digital photographic and map atlas of many fishes found along the Atlantic coast of the southeastern United States. Most photographs were taken by Fred Berry, during his years of ichthyological and fisheries research in the southeastern U.S., Bahamas, Caribbean and northern South America. Original 35-mm color transparencies were scanned and cataloged. Distribution maps for each species photographed were compiled by GIS analysis of the MARMAP fishery monitoring survey (1973-present), that has sampled fishes with a variety of methods, from Cape Hatteras to the Florida Keys. The completed atlas will be made available to scientists, educators and other users as a CD-ROM and interactive web site that will be indexed so that fish photographs and

distribution maps can be found by searching for common, scientific or family name. Eventually, the atlas will include other information as well, including species descriptions, life history information, and description of economic or cultural value.

***SEITZ, JASON C.; POULAKIS, GREGG R.**

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Non-fishery related anthropogenic and natural effects on the smalltooth sawfish (*Pristis pectinata*) in Florida, with a summary of these effects on sawfishes worldwide

Bycatch mortality in commercial net fisheries was the major reason for the decline of the endangered smalltooth sawfish, *Pristis pectinata*, in the United States. Although these net fisheries have been reduced or eliminated in some states, including Florida, other anthropogenic factors such as interactions with debris and rostrum removal may slow recovery of the sawfish population. We obtained entanglement, injury, and mortality data on *P. pectinata* not associated with net fisheries by soliciting information from anyone who encountered this species in Florida. Each informant was asked a series of questions including overall health of the fish, date and location of encounter, and estimated total length. Of the 3,240 encounters reported to us through 2004, 42 indicated an entanglement, injury, or mortality. Direct and indirect anthropogenic effects were most commonly reported (79%). These included individuals damaged by debris such as polyvinyl chloride pipes and elastic bands, caught without their rostra, killed by powerheads, and shot with arrows. Natural effects were less commonly reported (21%). Reports included attacks on *P. pectinata* by sharks as well as a mortality that coincided with a red tide event. Demand for sawfish parts for use in religious offerings, traditional medicine, and the fin trade have also affected sawfishes in other parts of the world. Sawfishes have been preyed on by sharks, crocodiles and dolphins, and have been trapped in drying water bodies in other parts of the world. Despite recent legislation, human activities remain a threat to *P. pectinata* in Florida and probably to sawfishes worldwide. Many people are still not aware of the endangered status of this species in the United States, but this can be ameliorated by incorporating education and awareness efforts as part of the management process. This study shows that although natural effects apparently do not present a major threat to sawfish in Florida, they should be monitored. In addition, more research and monitoring is needed to better understand the biology and ecology of *P. pectinata*, and the recovery obstacles faced by this species.

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Renal sexual segment of the Ground Skink, *Scincella laterale*

Mature squamates possess hypertrophied regions of the distal urinary ducts called the renal sexual segment (RSS). The RSS is believed to provide seminal fluid that mixes with sperm and is released into the female cloaca during coitus. This study is the first to describe ultrastructure of the RSS in a lizard collected throughout the active season. The species utilized, *Scincella laterale*, represents the largest family (1200 species) of lizards. Although sperm are present in the posterior ductus deferens of male *S. laterale* throughout the year, an annual spermatogenic cycle occurs that results in spermiation in spring, coinciding with maximum development of the RSS. Female *S. laterale* from this locality may possess stored sperm in vaginal crypts from March through May, and large oviductal eggs April through June. Thus, the correlation between mating and RSS activity observed in other squamates is also found in *S. laterale*.

Cytologically, the active RSS consists of columnar cells with numerous apical, electron-dense secretory vacuoles which are released by an apocrine process. The granules stain positively for proteins with bromphenol blue and react with PAS for neutral carbohydrates. After the mating season, the RSS undergo recrudescence, and the electron dense granules are replaced by a mucoid secretion that characterizes more proximal tubules throughout the year. Little variation in ultrastructure of the RSS occurs between *S. laterale* and *Cnemidophorus lemniscatus* (Teiidae), the only other lizard in which seasonal variation of the RSS has been studied using similar methods. Females exhibit differentiation similar to that of males in the distal urinary tubules, but to a lesser degree. This is only the second such report for female squamates, and the differentiation of the region in females is proposed to result from adrenal androgens.

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Comparative phylogeography of California amphibians and reptiles:
Insights from central California

Phylogeography has been justly criticized recently, particularly when single gene tree analyses are used to draw population and species-level inferences. However, when species are well-sampled, and particularly when the same phylogroups emerge across multiple taxa, even single gene studies can provide important insights into the historical processes leading to differentiation and speciation. We review four recent studies from our group of detailed, range-wide analyses of the western pond turtle (*Emys marmorata*: 73 populations/135 individuals), the California tiger salamander (*Ambystoma californiense*: 82/696), the red-legged frogs (*Rana aurora/draytonii*: 50/108) and the foothill yellow-legged frog (*Rana boylei*: 34/77). Although the ranges, habitats, and ecological details of the four

species differ, several consistent themes emerged across taxa. Santa Barbara County in coastal southern California harbored a deeply differentiated clade of *Ambystoma*, *Emys*, and (possibly) *R. boylei*, as well forming a contact zone between southern and central clades of *R. draytonii*. Molecular clock divergence time estimates based on penalized likelihood methods, and paleo-reconstructions of central California indicate that the region has been isolated for at least one million years, making it an important region of local endemism. The divergence of southern California and Great Central Valley taxa has been demonstrated in a variety of vertebrate taxa, and our work on *Emys* and *Spea hammondi* confirm this result. However, within the Great Central Valley, the southern San Joaquin Valley populations of *A. californiense*, *E. marmorata*, and *R. boylei* were all deeply differentiated; for the first two, the contact zone between phylogroups was identically situated. These and other results suggest that geologic and paleoclimatological events have consistently shaped the population history of these taxa, and that these differentiated regions should be taken into account for both conservation planning, and in models of speciation for co-distributed taxa.

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Spatial ecology and resource use by Florida cottonmouth snakes: Variation on a single island

Movement ecology of six individual cottonmouth snakes (*Agkistrodon piscivorus conanti*) was studied on a Florida Gulf Coast island during a 19-mo period in 2002-2004. Five snakes occupied habitat that was adjacent to, or beneath, avian rookeries where colonial nesting birds dropped or regurgitated fish that are consumed as carrion by snakes. The sixth snake overwintered some distance from a rookery and, during the warmer active months, ranged over much of the eastern end of the island where colonial bird nesting was absent. Snakes at rookeries evidently subsisted on fish that appeared to be plentiful, whereas the far-ranging snake was known to eat rats (*Rattus rattus*) in habitat where fish fall was absent. The far-ranging snake utilized a much larger area of habitat (15 ha) relative to that used by snakes at bird rookeries (0.5 to 1 ha), and also differed from others in having a lower body condition (6 g/cm body length vs. mean of 13.6 ± 1.7 g/cm). These data exemplify what we know to be general trends on the island. Cottonmouths are more numerous, move shorter distances, and have greater body condition at the west end of the island where bird rookeries are abundant and fish carrion more available relative to the eastern end. Movement differences of individual snakes appear to reflect foraging behaviors related to prey type and density.

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Formation and ossification of bony elements in the hands and feet of turtles

It has been suggested that the patterns of formation and ossification of the bony elements of the hands and feet of turtles are decoupled developmental processes. Decoupling of these developmental events is demonstrated by examining the precise orders of formation and ossification of skeletal elements in the hands and feet. We examined numerous embryos of the Red-eared Slider, *Trachemys scripta*, to document patterns of formation and ossification in the autopodium, and compared these patterns to similar data for several other species of turtles: Hawksbill Seaturtle (*Eretmochelys imbricata*); Spiny Softshell Turtle (*Apalone spinifera*); Common Snapping Turtle (*Chelydra serpentina*); and Alligator Snapping Turtle (*Macrochelys temminckii*). The patterns of formations of the forelimb and manus and hind limb and pes of *T. scripta* are consistent with those reported for other species of turtles. Formation proceeds along the primary axis, through Digit IV, with preaxial elements forming first and postaxial elements forming later. However, in comparisons made among all species, a major difference is observed in the sequences of ossification of the phalangeal elements. On the manus, phalangeal elements of Digits III and IV ossified first, whereas in the pes phalangeal elements of Digits I, III, and III ossify before those of Digit IV. Intra- and interspecific difference in the patterns of formation and ossification of the fore- and hind limb autopodium suggest that these are in fact decoupled developmental processes.

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Evolutionary and biogeographic history of the deepwater sculpin (*Myoxocephalus thompsonii*)

Deepwater sculpin (*Myoxocephalus thompsonii*) are considered to be Pleistocene glaciomarine relicts that are closely related to the arctic, marine-dwelling fourhorn sculpin (*M. quadricornis*). A previous genetic study on *M. thompsonii* examined only eight individuals from two lakes in North America and suggested limited genetic variation throughout their distribution. Here, I present the results of a range-wide genetic study of deepwater sculpin designed to resolve the evolutionary and biogeographic history of the species. Analysis of the mitochondrial DNA control region and ATPase 6,8 genes was carried out on deepwater sculpin from 26 inland lakes across Canada, as well as marine fourhorn sculpin from four locations across the Canadian arctic and landlocked (freshwater) fourhorn sculpins from two Canadian arctic lakes. The results confirm that deepwater sculpin are derived from fourhorn sculpin, but constitute a distinct species on genetic as well as ecological grounds. Based on the molecular data, inland incursion and subsequent species formation occurred in the early to mid-Pleistocene. In contrast to a previous study, two distinct mitochondrial haplotype-lineages of deepwater sculpin were identified within Canada. One lineage is entirely confined to Upper Waterton Lake, Alberta and

shows substantial genetic diversity, while the second lineage contains little variation but occurs throughout the species range. These contrasting patterns suggest that both ancient (Nebraskan) and recent (Wisconsinan) glacial events have shaped the evolution and biogeography of this species. The results have significant conservation implications, as the Great Lakes population of *M. thompsonii* is currently listed as threatened in Canada while inland populations, such as those in Upper Waterton Lake, are largely unrecognized and data deficient. **STOYE GENERAL ICHTHYOLOGY**

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Reptile road mortality around an oasis in the Illinois Corn Desert with emphasis on the Eastern Massasauga

Roads have numerous negative ecological effects on terrestrial fauna and vehicular traffic mortality can have significant demographic consequences in some species. We studied road mortality of reptiles around Carlyle Lake, Illinois, to assess the extent of the impact of vehicular traffic. Carlyle Lake, a popular tourism/recreation area, is situated in a larger agricultural landscape and is home to the largest Illinois population of the endangered Eastern Massasauga (*Sistrurus c. catenatus*). From April 2000 through November 2002, as part of a study on the Massasauga, we drove an approximately 26 km stretch of road around Carlyle Lake daily. We documented 321 cases of reptile road mortality (84 individuals of 6 turtle species and 237 individuals of 9 snake species). Overall, road mortality was highest in the spring and late summer/early fall. We recorded 42 cases of Massasauga road mortality with the highest number occurring in August. Road mortality was biased toward adult males whose movement patterns showed an increase in August that corresponded with the peak of the mating season. Based on our study on the ecology of this species, we are able to make recommendations to reduce road mortality that should aid in the conservation of the Carlyle Lake population.

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Fish communities of a disturbed mangrove wetland and an adjacent tidal river in Palmar, Ecuador

Mangrove wetlands serve as critical habitat for a variety of resident and transient fishes including many of economic importance. In spite of this, mangrove forests throughout the world are threatened by coastal development. On the coast of Ecuador, up to 50% of mangrove wetlands have been lost to development for shrimp farming. In this study, we describe the fish community inhabiting the remaining mangrove creeks of a heavily impacted mangrove wetland in Palmar, Ecuador, across multiple seasons. For comparison, we also describe the fish community of an adjacent tidal river lacking mangroves. We collected a total of 12,231 individuals comprising 36 species (16 families) using a seine. In terms of number of species per family, Gobiidae (7 species) was the most diverse for the mangrove sites followed by Gerreidae (5 species) and Engraulidae (4 species). For the tidal river sites, Carangidae (3 species) was the most diverse followed by Engraulidae and Gerreidae (2 species each). A total of 34 species were collected in the mangrove wetland, 21 of which were exclusive to the mangroves. A total of 14 species were collected in the tidal river, only 2 of which were exclusive to the river. The economically important, *Mugil curema* was collected in large numbers in both habitats. Species of Centropomidae, another economically important group, were caught exclusively in the mangrove habitat. Our results indicate that even a heavily impacted mangrove wetland potentially provides unique habitat for a suite of fishes when compared with a less structured habitat such as a tidal river.

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Preliminary results on the diet of the *Potamotrygon* species from Rio Negro Basin, Amazonas, Brazil

Potamotrygonidae family is the only group of elasmobranchs completely restricted to freshwater environments. Rio Negro is black water river system with low calcium level. The diet must be the main source of calcium uptake to freshwater stingrays species. The diet of three *Potamotrygon* species was assessed by stomach contents analysis of adult and juvenile forms of *Potamotrygon* cf. *histrrix*, *P. motoro* and *P. orbignyi*. The specimens were originally captured at night, using drill net with flashlights and battery. Adult forms of *P. motoro* were captured using long lines. The stomachs were fixed in 10% formalin solution and

conserved in 70% ethanol. The prey items were identified to the lowest taxonomic level possible. At the moment, 43 stomachs were analyzed (20 - *P. motoro*; 11 - *P. orbignyi*; 12 - *P. cf. histrix*). Preliminary results have shown all species exhibit a preference for small crustaceans, such as shrimps (59,26 %) from Euryrhynchidae and Palaemonidae families and crabs (37,04 %) from Trichodactylidae family. Small teleost fishes has a small contribution to diet of *Potamotrygon* species in this present study (3,70%). Capture-related signs of regurgitation were highest in *P. orbignyi* (05 stomachs). Nematodes and substrate were found, but it was not considered as prey items. The results obtained suggest that these species prefer benthic preys, with small participation of teleosts in their diet. At least for *P. motoro* was expected a higher contribution of teleost as prey item. During field trips this species is regularly observed feeding near water surface in the channel of Rio Negro.

SHINE, RICHARD

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In pursuit of the rainbow serpent: Reflections on python research

This talk will present a highly-biased personal perspective on what I and my collaborators have learnt about pythons over the last two decades, why those studies took the form they did, and what might be productive themes for future research on giant snakes. In particular, I will focus on the ways that water python populations respond to annual variation in climatic conditions, mediated via effects of rainfall on their rodent prey; on the remarkable intraspecific diversity in mating systems and sexual size dimorphism found within carpet pythons; on the impact of commercial harvesting on Indonesian python species; and on the research opportunities offered by the facultative endothermy (shivering thermogenesis) so widespread in brooding female pythons.

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Deep-sea fish fauna of the Sea of Japan

The deep-sea fish fauna of the Sea of Japan is investigated based on specimens and literature. This sea is over 3000 m deep, but is connected to adjacent seas via shallow straits (15-140 m depths) which may prevent deep-sea species from dispersing and/or invading. Although the Sea of Japan had been well known to lack primary deep-sea fishes, except *Maurolicus japonicus* (Sternoptychidae), our literature survey reveals the chimaerids (3 spp.), atelepodids (2), myctophids (2), macrourids (2) and ceratiids (1) had been reported at least from there. We introduce a preliminary list of deep-sea fishes found in the Sea of Japan, showing their names and the number of specimens, totaling 225 species in 88 families. Most of the families are represented by 1-5 Sea of Japan species, except Zoarcidae (28 spp.) and Pleuronectidae (16). Our results support the small numbered primary deep-sea fishes there and reveals that the species richness is very low

compared to adjacent seas as Tosa Bay (Shikoku Island, Japan) and Ryukyu Islands, whereas slightly low to that of Pacific side of Tohoku District (northern part of Honshu Island, Japan). The species composition of this sea may be related with the geological history and unique oceanographic characters.

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Reproductive biology of *Mustelus schmitti* Springer, 1939 (Triakidae: Carcharhinidae) from Buenos Aires province, Argentina

In the present study the reproductive biology of *M. schmitti* collected from the commercial bottom trawl fishery operating in Puerto Quequén, Argentina was investigated. The specimens were sampled during 2003–2004 seasonally. The number of sharks collected was 637 (298 males and 339 females). There were 190 pregnant females that contain 1,103 embryos. The size ranged from 419 to 819 mm total length (TL) for males and from 417 to 951 mm TL for females. The relationship of TL and body weight was different between sexes ($P < 0.05$). In contrast, the embryos did not show differences between sexes ($P > 0.05$). The size frequency showed that females attain larger length and weigh than males. Fifty percent (50%) of maturity size showed that males mature at a lower TL (567 mm) than females (598 mm). We found that the left testis reached larger weigh and length than the right one ($P < 0.01$). The average values of the IG and IH per season varied significantly for males and females. The average values of the white and yellow ova per season showed significant differences ($P < 0.05$). The maximum diameter of the left oviducal gland was greater than the right one ($P < 0.05$). At greater TL the females had more embryos per brood ($P < 0.01$) than bigger puppies ($P > 0.05$).

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Unequal morphological diversification in sister clades of characiform fishes

When do sister clades differ so much in morphological diversity that the tempo or mode of evolution must have differed between them? Despite identical ages of origin, similar net speciation rates and broadly overlapping geographic distributions, the morphological and ecological diversity of the South American fishes in the superfamily Anostomoidea (Anostomidae + Chilodontidae) dwarfs that of the fishes in their sister-group, the equally species rich Curimatoidea (Curimatidae + Prochilodontidae). This study investigates the origin of this unequal diversification by combining simulations of cladogenesis with models of morphological drift in an empirically determined morphospace. These simulations determine the relative likelihood that any given combination of the

rates of morphological evolution, speciation and extinction produced the observed morphological diversity of each modern clade. A likelihood approach is used to determine which, if any, of these evolutionary rates must have been elevated in the Anostomoidea relative to the Curimatoidea. The rate of morphological change, expressed as the variance in change per lineage per unit time, is found to be the primary determinant of morphological diversity, with the rate characteristic of the Anostomoidea likely to have been between 1.6 and 3.0 times that of the Curimatoidea. Variation in the absolute rates of speciation or extinction is unlikely to explain the observed inequality in morphological diversity. Uniquely derived morphological and ecological features that may have accelerated or decelerated the rate of morphological change in these fishes are identified and discussed. **STOYE GENERAL ICHTHYOLOGY**

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A Bayesian approach to estimating asymptotic size without age data

The von Bertalanffy growth equation is commonly used in ecology and fisheries management to model individual growth of an organism. Generally, a nonlinear regression is used, with length-at-age data, to recover key life history parameters: L_{∞} (asymptotic size), k (the growth coefficient), and t_0 (the time when size is zero). However, age data are often unavailable for many species of interest, which makes the regression impossible. To tackle this problem, we have developed a Bayesian model to find L_{∞} using only length data. We use length and age data for female Blue shark, *Prionace glauca*, and although we are only using lengths in our model, we use the corresponding age data to perform the traditional regressions. Our method is not specific to Blue shark, but rather it is a general model that can be used with any length data. Preliminary comparisons of our model output and the results of a nonlinear regression using the von Bertalanffy growth equation show similar estimates of L_{∞} . Our work will facilitate more detailed stock assessments of species for which age data are sparse.

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Food habits of diamondback terrapins at Jamaica Bay Wildlife Refuge, New York

Diamondback terrapins (*Malaclemys terrapin*) are one of the few brackish water turtles. Few dietary studies have been done on terrapins, and most information on their diets is anecdotal. Fecal samples were collected from female terrapins coming ashore to nest in June. One set of samples were collected by soaking the females in fresh water for 24 hours. A second set of samples were collected by stomach flushing. We compared the total prey species list and prey body sizes from these two sources, and found that they did not differ. Therefore, we recommend that soaking terrapins be used to collect dietary study samples

wherever possible because it is less disruptive to the terrapin.

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Population structure and stability of the bluemask darter, *Etheostoma (Doration)* sp.

The bluemask darter, *Etheostoma (Doration)* sp., is an endangered fish endemic to the upper Caney Fork system in the Cumberland River drainage in central Tennessee. Little is known about the life history of this species and an understanding of population structure and stability is necessary to implement management and recovery actions. A total of 2926 bluemask darters was collected from the Collins River between July 2001 and September 2003. Additionally, 842 bluemask darters were collected from the Rocky River in 2002. Length-frequency analysis indicated the presence of four age-classes in both rivers. In each river, the majority of the population was comprised of fish < 3 years old. Differences in age-class structure among years reflected variable year-class strength in the Collins River. Male and female growth rates differed significantly ($P < 0.05$); males were typically larger than females of the same age and the majority of age 3 individuals were males. Growth rates in the Collins and Rocky Rivers were similar for each sex ($P > 0.05$). In both rivers, females were more abundant than males.

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What we know about cypriniform relationships: a review of the evidence.

The order Cypriniformes contains the minnows, suckers, loaches and algae eaters. There are over 3,285 described species in 280 genera and five families. These fishes are widespread in Africa, Asia, Europe, and North America, and an important constituent of freshwater ecosystems. In spite of their near ubiquity and importance, there have been few attempts to conduct large-scale overviews of cypriniform systematics; most studies focus on restricted sets of taxa. Thus, we do not have a clear idea of relationships between or within families. One of the goals of the Cypriniformes Tree of Life Project (CToL) is to generate a phylogenetic hypothesis of Cypriniformes using molecular and morphological characters. As part of this effort, I will review previous studies of cypriniform relationships and evidence for monophyly of higher taxa, highlighting areas of controversy in cypriniform systematics including problematic taxa and characters.

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Population status of 14 shark species caught in the KwaZulu-Natal beach protection program

Shark nets have been set off the beaches of KwaZulu-Natal, South Africa, since 1952 to minimize risk of shark attack. The nets fish in fixed localities 400 m from shore and both directly impact local shark populations and act as fisheries-independent monitoring devices. Reliable catch information at the species level was available for the period 1978-2003. Trends in catch rate and size were used to assess the population status of 14 commonly caught shark species. In addition, a demographic modeling approach was used in conjunction with the catch information to assess the potential impact of the nets. Catch rates of four species (*Carcharhinus leucas*, *C. limbatus*, *Sphyrna lewini* and *S. mokarran*) showed a significant decline, as did the mean or median length of three species (*Carcharhinus amboinensis*, *C. limbatus* and *Carcharodon carcharias*). The catch rate of *Galeocerdo cuvier* increased. For most species that showed declining catch rates or median length the potential impact of the shark nets was assessed to be low, suggesting that other sources of catch were responsible for the declining status. The potential impact of the shark nets was assessed to be high for two species (neither of which showed declines in catch rate or median length), because of very low intrinsic rates of population increase.

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The occurrence of a Great White Shark, *Carcharodon carcharias*, in a southern New England tidal estuary

On September 21, 2004, a great white shark, *Carcharodon carcharias*, entered a shallow southern New England coastal estuary in Naushon Island, Massachusetts. The tidal estuary of approximately 0.03km² has a maximum depth of 6m and two inlets, a narrow (8m) bridge-covered channel to the north and a broader (35m), yet shallow (<1m), southern outlet. The white shark, an immature female with an estimated total length and weight of 430cm and 770kg, respectively, remained in the estuary for 14 days. During this period, the shark repeatedly traversed the estuary, occasionally swimming into very shallow depths (<1m), yet seemingly unwilling to exit the estuary, regardless of the tide. After close observation of the animal over several days, it became apparent that the shark was not likely to exit the area through either point of egress. Hence, actions were taken to motivate the shark to leave the estuary. First attempts involved the less obtrusive use of methods that appealed to its visual, chemosensory, and electrosensory capabilities, yet the shark demonstrated little to no reaction to a number of stimuli. Ultimately, the shark was herded through

the shallow southern channel and into the open water of Vineyard Sound with the combined use of weir netting and water pumps. Although the shark was tagged with a standard NMFS tag and a pop-up archival transmitting tag, the latter shed prematurely. Archived depth data collected by the tag showed that the shark exhibited a marked semi-diurnal preference for deeper depths that correlated closely with tide and currents in the estuary. This behavior may be indicative of an energetic response associated with swimming in a tidal estuary with high current velocities.

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Effects of Rainbow Trout upon a native Appalachian cyprinid

Rainbow Trout (*Oncorhynchus mykiss*) are a non-native fish stocked for a put and take sport fishery within the southeastern United States. There is little information on effects of stocked rainbow trout upon non-game fishes. Consequently, we quantified the behavioral responses of warpaint shiner (*Luxilus coccogenis*), a native Appalachian cyprinid, to rainbow trout in an experimental stream. We selected warpaint shiners as our experimental species both because they are common and may serve as a proxy species for threatened and endangered cyprinids. We examined micro and meso habitat preference, prey capture success, and intraspecific and interspecific aggression of the warpaints before and after the introduction of a hatchery trout at both spring/fall (12C) and summer temperatures (17C) and at both high and low fish density (5 and 2 fish, respectively). In addition, we used a river chub (*Nocomis micropogon*) treatment to determine whether the warpaint response was trout-specific response or a general large fish response. Preliminary analyses indicated that density, trout and chub all produced significantly different microhabitat and mesohabitat usage by warpaints. The presence of trout had a slight effect upon warpaint foraging rate, however these analyses are not yet complete. We are also currently in the process of analyzing inter and intraspecific aggression. The present experiment is a component of a larger project with the Georgia Department of Natural Resources in which we are quantifying both fish assemblage structure and habitat use in an Appalachian stream both before and after rainbow trout introduction.

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Diet analysis of the exotic catfish, *Pterygoplichthyes disjunctivus*, in Volusia Blue Springs, Florida

The exotic catfish, *Pterygoplichthyes disjunctivus*, has established a large breeding population in Volusia Blue Springs over the past five years. Since their impact on the springs ecosystem is as yet unknown and there is very little information on their biology in the literature, we undertook a gut content analysis during the

summer and winter of 2004/5. Gut contents of summer and winter fish were analyzed and compared with each other and with algal samples taken from the same areas of the run where fish were collected. Preliminary data show that both summer and winter *Pterygoplichthyes* had, on average, 12 species of filamentous algae or diatoms in their guts. There were, however, significant differences in diet composition between the summer and winter, as well as between seasonal diet composition and available algae in the run. Additionally, we found that *Pterygoplichthyes* had significantly more in their guts during the summer than in winter.

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Influence of forestry best management practices on fish communities in first-order streams in north-central Mississippi

Forestry best management practices (BMPs) have been designed to minimize the impacts of timber harvesting and other forestry operations on water quality. Previous studies evaluating the influence of forestry BMPs on streams have focused on examining the physicochemical responses. Information on how forestry BMPs influence stream fish communities in Mississippi and other parts of the southeastern United States is lacking. We sampled fishes and physical habitat three times a year from Fall 1999 until Spring 2002 from fourteen streams within pine plantations of north-central Mississippi. Streams received one of three timber harvesting regimes: 1) reference - no timber harvesting or other forestry practices conducted in the watershed during the study; 2) BMP - clearcut timber harvesting conducted in the watershed with use of streamside management zones; and 3) clearcut - clearcut timber harvesting conducted in watershed without forestry BMPs. Additionally, fish and habitat sampling was conducted before implementation of timber harvesting regimes and one and two years after timber harvesting. Two factor repeated measures ANOVAs indicated that the pattern of mean fish species richness, evenness, and abundance among sampling periods did not differ among timber harvesting regimes. An indirect gradient analysis found that fish communities were more strongly correlated with instream habitat variables that exhibited temporal variation, than logging intensity in the watershed. Our results suggest that forestry best management practices that prevent changes in hydrology, canopy cover, and water temperature will assist with reducing the impacts of timber harvesting on fish communities in first-order streams within pine plantations in north-central Mississippi.

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Evaluating habitat and fish community responses to conservation practices in headwater streams of Upper Big Walnut Creek

The Upper Big Walnut Creek watershed (USGS HUC 0506001-130) is located north of Columbus, Ohio, and serves as source water for 800,000 residents of Columbus. Streams in the watershed flow into the Hoover Reservoir, and then downstream into the Scioto River. The Upper Big Walnut Creek watershed contains mostly low gradient warmwater streams adjacent to row crop agriculture. Soils in the watershed exhibit slow water permeability, which in conjunction with extensive agricultural land use has led to the widespread use of tile and surface drains to facilitate drainage of agricultural fields. Previous research has documented that the majority of headwater streams in the Upper Big Walnut Creek watershed are impaired by nutrient enrichment, pathogens, and habitat degradation stemming from current agricultural management practices. We are evaluating the influence of conservation practices on the physical habitat and fish communities of headwater streams in this watershed as part of the Source Water Protection Research Initiative and the Conservation Effects Assessment Project (CEAP). Our hypothesis is that implementation of conservation practices in headwater streams of Upper Big Walnut Creek will alter the physical habitat of the riparian zones which will in turn lead to changes to the water chemistry, instream habitat, and fish community structure within these small streams. We began monitoring water chemistry parameters in 2003, and measurements of riparian vegetation, channel geomorphology, hydrology, and fishes began in April 2005. We plan to assess changes in physical habitat and fish communities through time with univariate statistics, and indirect gradient analyses will be used to examine the relationships between physical habitat and fish communities.

***SMITH, DANNA B.; QUALLS, CARL**

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Habitat variation and herpetofaunal communities of the longleaf pine ecosystem in south Mississippi

The habitat associations of reptiles and amphibians endemic to mesic and xeric longleaf pine forests in southern Mississippi are scanty studied and poorly understood. Many species indicative of these communities are both fossorial and elusive, thus difficult to capture and study. The objectives of this study were: (1) identify the best remaining longleaf pine habitat in southern Mississippi and survey the reptiles and amphibians in this habitat (2) determine the levels of habitat heterogeneity between these sites and (3) determine if there are differences in reptile and amphibian community composition between these sites and, if differences occur, to what degree community difference can be explained by habitat variation. From March through July 2004, twenty-two longleaf pine communities located in ten counties were surveyed in southern Mississippi. Drift fence arrays with pitfall and funnel traps, manual searching, and road cruising

were used to survey each site. In total, thirty-five reptile species (502 individuals) and eighteen amphibian species (853 individuals) were detected during this period. For each site, the following habitat characteristics were collected and quantified: basal area, recency of fire, slope, percent sand, silt and clay content of soil, percent tree canopy cover, percent mid-story coverage, percent forbs, grasses, shrubs, woody vines, bare soil and leaf litter comprising groundcover, and dominant overstory, mid-story, and shrub species. The herpetofaunal abundance and diversity for each site and the quantified habitat variables were analyzed using multivariate techniques to search for patterns of variation and covariation in habitat and herpetofaunal communities. Principal components analysis coupled with analysis of similarity revealed three significantly different longleaf pine habitat types, and correlated variation in reptile and amphibian communities among these habitat types. By better defining the faunal-habitat relationships of these communities, the natural history and ecology of many longleaf pine resident and specialist species may be better understood. **SSAR SEIBERT ECOLOGY**

SMITH, GERALD

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Centrarchid paleoecology reconstructed from fossil distributions, morphology, and growth

Centrarchids are 30 North American species that inhabit low-gradient, warm waters from southeastern Canada to northern Mexico. The richest fossil record occurs in western North America from Alaska to the Mexican Plateau, although there is currently only one western species, *Archoplites interruptus*, in the Sacramento drainage. Several species of *Archoplites* existed in the late Cenozoic of Western North America. Other western centrarchids have been assigned to three additional extinct genera. Centrarchids are generally deep-bodied species of lakes and lowland rivers, found below 1000 m elevation, with few exceptions. Growth and reproduction of most centrarchids is limited to areas with at least 120 frost-free days. The oldest species is an *Archoplites* from 14 Ma Miocene of northern Idaho. Miocene and Pliocene *Archoplites* of rift lakes in southern Idaho were long-lived and as large as crappies, e.g. 30-40 cm SL. A 3-year life cycle characterized the small, molariform-toothed, species from the late Pliocene of Central Washington. Widespread populations in the intermountain west went extinct where aridity developed or where Pleistocene growing seasons were reduced below the 120-day threshold. Mio-Pliocene fossil forms were deep-bodied insectivores, piscivores, and molluscivores. Those from the Pliocene and Pleistocene of eastern U.S. were taxonomically and ecologically similar to Recent forms, with no known extinction. Early post-glacial appearance (12,000 B.P.) of green sunfish in Michigan suggests northward headwater stream capture.

SMITH, KEVIN G.

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Patterns of nonindigenous herpetofaunal richness and biotic homogenization in Florida

Recent analyses suggest that a few key biogeographic and anthropogenic factors can explain geographic variation in nonindigenous species richness. However, no such analysis has examined patterns of nonindigenous herpetofaunal richness for similar trends. This is an important omission, since there are several injurious invasive amphibians and reptiles and some regions contain many nonindigenous herpetofaunal species. To address this omission, I used multiple regression analysis to identify ecological and geographic factors that relate significantly with nonindigenous herpetofaunal richness among the counties of Florida, USA. I also used the Jaccard similarity index to determine if nonindigenous species tend to homogenize or differentiate the herpetofaunas of a subsample of Floridian counties. In the multiple regression, county latitude strongly and negatively related with nonindigenous herpetofaunal richness, explaining approximately two-thirds of the variation in this variable. To a smaller degree, human population and university presence both related positively with nonindigenous herpetofaunal richness. Several other variables, including county land area, were not significantly related to nonindigenous herpetofaunal richness. The consistent importance of human population to nonindigenous species richness in this and past studies suggests that the influence of anthropogenic factors is universal and may be as important to nonindigenous species richness as are natural biogeographic factors that generally relate with native species richness. No evidence of significant homogenization was found based on Jaccard index values. However, a significant relationship between homogenization scores and geographic distance suggests that the effect of nonindigenous herpetofaunal richness on the similarity of county biotas is scale-dependent, such that adjacent counties tend to experience homogenization, while distant counties tend to experience differentiation as a result of the presence of nonindigenous herpetofauna. The results of this study may be helpful in controlling the introduction and spread of nonindigenous species and in evaluating the effects of such species on native biodiversity.

**SMITH, LORA L.; STEEN, DAVID A.; *MILLER, GABRIEL J.;
STERRETT, SEAN C.**

Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 39819, USA

Herpetofauna of Ichauway: Diversity, habitat and current research

At the Joseph W. Jones Ecological Research Center we are currently conducting a number of studies to better understand the ecology of amphibians and reptiles of the Southeast. Studies include efforts to determine the role of amphibians in isolated wetland food webs, the influence of predators on Gopher Tortoise nest success and hatchling mortality and the effect of an introduced invertebrate on the diet of Barbour's map turtles. We are also gathering data on the spatial ecology of Tiger Salamanders, Gopher Tortoises, Mud and Chicken Turtles.

***SMITH, LORA L.; STEEN, DAVID A.; HOSS, SHANNON K.;
MILLER, GABE J.; STERRETT, SEAN C.; BORG, CHRIS**

*Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 39870,
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Patterns of amphibian migration at a depressional wetland in southwest Georgia

We examined migration patterns of amphibians at a drift fence around a depressional wetland in southwest Georgia. The study wetland lies within a landscape of intact fire-maintained longleaf pine savanna, mixed-hardwood forests, and wildlife food plots, which allowed us to evaluate movement patterns within a complex habitat matrix. The specific objectives of the study were to 1) evaluate spatial movement patterns of select amphibian species at a breeding wetland; and 2) determine if spatial movement patterns of these species might be explained by surrounding land cover type. Among three of the more frequently captured species, Eastern tiger salamander (*Ambystoma tigrinum tigrinum*), Southern Toad (*Bufo terrestris*), and Eastern Narrowmouth Toad (*Gastrophryne carolinensis*), the different sex/age classes tended to enter and exit the wetland from the same general direction and the distribution of captures of these species around the wetland edge were non-random. Results of ordination analysis to identify possible terrestrial habitat associations for these species will be discussed.

SMITH, M. ALEX; *GREEN, DAVID M.

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Complex phylogeography of Fowler's Toad, *Bufo fowleri*, at its northern range limit

Many of the species of amphibians and reptiles that recolonised previously glaciated areas in the Great Lakes basin of North America over the past 10,000 to 12,000 years exhibit genetic evidence of multiple invasion routes and present-day secondary contact between deeply divergent lineages. With this in mind, we investigated the phylogeographic structure of genetic variability in Fowler's toad (*Bufo fowleri*) at the northern edge of its distribution where its range encircles Lake Erie. Because *B. fowleri* is closely tied to habitats along the Lake Erie shoreline, we would expect that the species' colonization of the northern shore would have been limited to a small number of possible dispersal routes. Thus there should remain genetic evidence of the number of invasions that took place. A 540 bp DNA sequence from the mitochondrial control region of 158 individuals from 21 populations was amplified and its variation analyzed. Inter-population sequence variation ranged from 0% to 6%. Phylogenetic analysis of p-distance using the neighbor-joining method revealed two deeply divergent (6% sequence divergence) mtDNA lineages. Additional mitochondrial (CO1) and nuclear (ITS1) markers were also sequenced and analyzed. The two major lineages discerned with this multi-gene approach may possibly have arisen due

to secondary contact of populations that entered the region via separate routes. However, the phylogeographic pattern is not simple. The populations of toads at Long Point, on the north shore of Lake Erie, clustered with the population from Indiana Dunes on Lake Michigan to form Phylogroup 2 whereas all other *B. fowleri* populations examined from both sides of Lake Erie constituted Phylogroup 1. Furthermore, mtDNA sequences from the related species, *Bufo americanus*, obtained from populations outside the range of *B. fowleri*, clustered with mtDNA haplotypes of *B. fowleri* Phylogroup 1, indicating the possibility of partial introgression of mitochondria from one species to the other.

SMITH, MATTHEW T.

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Head shape variation between sexes and geographic regions in the Prairie Rattlesnake (*Crotalus v. viridis*)

Many snake species are sexually dimorphic for traits such as size and scale counts. While the pattern of sexual size dimorphism varies among snake species, North American rattlesnake species typically exhibit a male biased sexual size dimorphism. Given size and scale count dimorphisms in rattlesnakes, one might expect other traits such as shape to be sexually dimorphic. In the current study, I examined head shape variation among populations and between males and females in populations of prairie rattlesnakes (*Crotalus v. viridis*) located in North and South Dakota. Dorsal head shape was quantified using landmark-based geometric morphometrics (GM) on digital images captured from live snakes. These types of analyzes have typically been conducted on preserved specimens, so this study also offers a new technique for obtaining dependable digital images for use in GM techniques. Multivariate analyses of variance (MANOVA) were performed on shape variables generated from GM methods for models with all possible combinations of independent variables including sex, geographic region, snout-to-vent length (SVL), and all possible interactions. MANOVA indicated a significant variation in head shape among regions and between sexes. Further analyses of nested models using a Wilks likelihood ratio indicated that the contribution of sexual dimorphism to overall shape variation was not significant when compared to those contributions of geographic region and SVL. I conclude that while head shape may be sexually dimorphic, the difference in shape between sexes is slight when compared to regional differences. Therefore, future studies on sexual shape dimorphism should account for these geographic differences.

SMITH, MICHAEL E.; *LUJAN, NATHAN K.; HUMPHRIES, JULIAN

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Acoustic function of the encapsulated swimbladder of loricariid catfishes

Loricariid catfishes feature a highly derived swimbladder morphology characterized by complete division of the bladder into two separate spheres that are each surrounded by a megaphone-like bony capsule. Several structural features of this swimbladder capsule apparatus have been hypothesized to have

acoustic functionality, but little is understood about either the morphological range of these structures in the family Loricariidae, or about their acoustical functionality. The bony capsule may serve to reflect and concentrate acoustical energy towards the tripus, or it may mechanically interact with the swimbladder to change or stabilize its resonance properties in an acoustically functional manner. X-ray CT images of the loricariid swimbladder capsule apparatus are presented with preliminary auditory brainstem response measurements of acoustical sensitivity in morphologically disparate species, and potential relationships between the two will be discussed.

***SMITH, WADE D.; PEREZ, COLLEENA; EBERT, DAVID A.**

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Growth of the California skate, *Raja inornata*: Assessment of multiple ageing structures and somatic growth models

Elasmobranch size-at-age estimates are predominantly derived from vertebral band counts and modeled using a three parameter von Bertalanffy growth function. However, alternative ageing structures and growth models may provide improved descriptions of species' growth. The objectives of this study were to examine the applicability of non-traditional calcified structures as reliable size-at-age estimators and to describe the somatic growth characteristics of *Raja inornata*, a nearshore skate species for which no previous life history information has been published. Relationships between ageing structure and specimen sizes were used to assess the assumption that the structures increase proportionally to specimen size. Precision among caudal thorn, neural arch, and vertebral centrum age estimates were evaluated using tests of symmetry and analysis of variance to determine the most suitable structure. The temporal periodicity of band deposition was examined using modified centrum edge and marginal increment ratio analyses as semi-direct methods of validation. Disc width-, total length-, and weight-at-age estimates were fitted to polynomial, two parameter von Bertalanffy, three parameter von Bertalanffy, Gompertz, and Schnute growth functions. Models were developed from female and male size-at-age data separately and combined and analyzed by analysis of residual sums of squares to determine if calculated parameters are equivalent between the sexes. The most appropriate growth model was selected based on parsimony and goodness-of-fit using Akaike's information criterion and standard errors of model estimates.

SMITH, WM. LEO

American Museum of Natural History, Dept. of Ichthyology, Central Park West at 79th Street, New York, NY 10024, USA

Evolution and relationships of venomous spiny-rayed fishes (Teleostei: Acanthomorpha)

Knowledge of evolutionary relationships of species, or phylogeny, allows for effective predictions about the unstudied characteristics of species. These include the presence and biological activity of an organism's venoms. To date, most

venom bioprospecting has focused on snakes, resulting in six stroke and cancer treatment drugs that are nearing US-FDA review. Fishes, however, with thousands of venoms, represent an untapped resource of natural products. The first step involved in efficient bioprospecting of these compounds is a phylogeny of venomous fishes. This study will show the results of such an analysis, including the first explicit suborder-level phylogeny for spiny-rayed fishes. The resulting phylogeny, based on the analysis of approximately 4,700 aligned base pairs from five mitochondrial and nuclear genes in 233 species (228 acanthomorphs), suggest that more than 500 acanthomorph fish species in eleven clades should be presumed venomous. After completing this molecular phylogeny, more than 100 species in 43 acanthomorph families were dissected and examined for both the presence of a venom delivery structure and a conspicuous venom gland. This morphological examination was designed to test the effectiveness of the phylogeny for predicting the distribution of venomous spiny-rayed fishes, focusing on species that are predicted to be venomous, listed as possibly venomous in the literature, or that were closely allied to venomous clades in the resulting phylogeny. The results of the morphological examination provide evidence that the molecular phylogeny is highly effective at predicting the presence or absence of venom glands in spiny-rayed fishes. The combined molecular and morphological results from this study provide the necessary roadmap for the efficient discovery and exploitation of novel structures from piscine venoms that have desirable qualities for use as research tools or lead compounds for drugs. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

***SMOLENSKY, NICOLE; FITZGERALD, LEE**

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Population density estimates of the sand dune lizard

Sceloporus arenicolus, sand dune lizard, is endemic to the Mescalero Sands ecosystem of southeastern New Mexico and adjacent Texas. Oil and gas development is causing fragmentation of *S. arenicolus* habitat, but the extent to which development depresses lizard populations is not known. The primary objective of our study is to estimate population densities of *S. arenicolus* and other syntopic lizards at a series of sites ranging from pristine condition to severely disturbed. Our surrogate measure for habitat disturbance is the density of caliche roads and oil well pads. Surveys will be conducted using the Distance sampling technique and analyzed using the DISTANCE software program. To calibrate population density estimates, we will compare the estimates from transect surveys to actual densities obtained from total removal plots. Removal plots will consist of 10 x 10 m² fenced plots in which all animals and vegetation are removed. We will present preliminary findings from May and June 2005. This study will provide important information on population densities of *S. arenicolus*, throughout the majority of its range and will be useful for ongoing management and conservation efforts aimed at protecting this threatened species.

SNODGRASS, JOEL W.

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Implications of wetland landscape modification resulting from storm water retention ponds

In most jurisdictions, creation of storm water retention ponds is required as part of land development plans. While retention ponds are primarily designed to mitigate impacts of runoff from impervious surfaces to receiving waters, they provide habitat for wildlife such as pond-breeding amphibians. Because retention ponds provide habitat for only a subset of the pond-breeding amphibians potentially found in a landscape, an understanding of the effects of retention pond creation on breeding habitat availability is required to assess potential changes in amphibian assemblages accompanying human landscape development. To assess the influence of retention pond creation on breeding habitat availability I used a sequence of aerial photographs to document changes in the abundance and distribution of ponds and other wetlands in the Red Run watershed, a third-order watershed in Baltimore County, Maryland, USA. While there was an increase in human-created wetlands, natural wetland area changed little over a ten-year period (1990 to 2000) of intensive development. Over the ten-year study period, total area of wetlands in the watershed increased approximately 3-fold, from < 8% to nearly 35% of the watershed area, and the number of individual wetland patches doubled from 0.26 wetlands/ha to 0.44 wetlands/ha. Because of the differential ability of pond-breeding amphibians to utilize retention ponds as breeding sites, the increase in retention ponds accompanying recent development has the potential to greatly alter amphibian assemblage structure at the scale of small watersheds.

***SNYDER, DAVID B.; LINDEMAN, KEN C.**

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Microhabitat use by newly settled fishes on hardbottom habitats in nearshore waters of southeast Florida

Use of natural and artificial microhabitats was examined by comparing biotic and abiotic substrate characteristics within quadrats occupied by newly settled fish to substrate characteristics in randomly chosen quadrats within the same locations. Data were collected during spring and summer of 2003 and 2004 in coastal waters off southeastern Florida. Quantitative photography was employed to assess percent cover of substrates used by newly settled *Haemulon* spp., *Anisotremus virginicus*, *A. surinamensis*, *Pempheris schomburgkii*, *Stegastes variabilis*, *Bairdiella sanctaluciaae*, and *Equetus* spp. Discriminant function analyses revealed that most sites occupied by fishes differed significantly from randomly chosen sites at natural and artificial locations. However, sites used by several taxa were poorly classified by the analyses. Microhabitat characteristics most important in distinguishing sites used by individual taxa will be discussed. These data are being applied in management analyses to determine the efficacy of artificial hardbottom as partial mitigation for losses of natural hardbottom due to coastal construction activities.

***SOMMER, JULIE A.; BROZEK, JEREMY M.; BESSERT, MIKE; LI, CHENHONG; BERRA, TIM M.; ORTI, GUILLERMO**

(JAS, JMB, MB, CL, GO) *University of Nebraska Lincoln, School of Biological Sciences, Lincoln, NE 68588, USA; (TMB) Ohio State University, Dept of Evolution, Ecology, and Organismal Biology, Mansfield, OH 44906, USA*

Microsatellite assessment of parentage in the nurseryfish, *Kurtus gulliveri* (Perciformes: Kurtidae)

Polymorphic microsatellite loci were isolated and employed to assess the parentage of egg masses carried on a hook by the male nurseryfish, *Kurtus gulliveri*. The various reproductive behaviors and the high frequency of male parental care in fishes make them excellent candidates for testing the evolution of mating systems. *K. gulliveri* exhibits male parental care, however, spawning behavior has not been observed. Evolutionary theory predicts that such an investment in parental care would have a genetic reward, i.e. that the male is carrying eggs that he fertilized. A parentage assessment is needed to gain an understanding of the mating system of this species. Males of *K. gulliveri* have a morphologically unique hook, originating from the supraoccipital bone and are the only known fish that brood eggs on the forehead. It is hypothesized that engorgement of the hook clamps the egg mass into place. An intriguing branching network of filaments interconnects the embryos into a lobed mass. The goal of this study was to assess if the male carrying the egg mass is the genetic father or if multiple males and females are represented in each mass. Adult nurseryfish were genotyped for all polymorphic loci, allele frequencies were determined, exclusion probabilities were calculated, and a subset of each egg mass and the associated males were used to assess parentage. Parentage assessments in natural systems with powerful polymorphic markers, such as microsatellites, have increased accurate parentage assignments thereby playing a major role in the study of evolution and behavior in taxa whose natural history is unknown.

SONNTAG, EDYTHE L.

Detroit Zoological Institute, Department of Herpetology, National Amphibian Conservation Center, 8450 West Ten Mile Road, Royal Oak, MI 48068, USA

Feasibility study for the translocation of Blanchard's cricket frogs (*Acris crepitans blanchardi*) to the Detroit Zoological Institute's restored wetlands: Habitat requirements and considerations

Although still common in much of its historic range, populations of the Blanchard's Cricket Frog (*Acris crepitans blanchardi*) are declining in the northeast portion of its historic distribution, and it is now a Michigan Species of Special Concern. In 2004, the Detroit Zoological Institute's National Amphibian Conservation Center initiated a study to determine the feasibility of translocating *Acris* to the restored wetlands on zoo grounds by first characterizing the population dynamics and habitat requirements. Habitat fragmentation and loss, as well as other factors, have left only two populations in southeast Michigan, with one being seriously threatened by development. The Zoo's vision is to

establish self-sustaining satellite populations of this species on zoo grounds and in other protected areas in southeast Michigan. My intention was to determine if the habitat on zoo grounds was a viable option for translocation. Characterizing habitat features such as shoreline slope, water quality, climatic conditions, surrounding land use, and vegetative community structure allowed comparison between extant population sites and potential release sites. A basic assessment of species of invertebrates, fish, amphibians, reptiles, and mammals that coexisted in the area was also conducted. Using GIS mapping, it was possible to correlate habitat structure and same- year encounter data to identify the preferred microhabitat for this species. These results were then applied to the assessment of all potential release sites, as well as to make recommendations for the mitigation of the one construction-impacted population.

***SPAETH, JOHN P.; SCHAEFER, J.; KREISER, B.; RAMIREZ, R.**

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The effects of unfavorable habitat on the dispersal of *Campostoma anomalum* (Cyprinidae) as measured by microsatellites

Riverine landscapes have numerous features that can affect the dispersal of stream-dwelling fish populations. Physical barriers are known to limit dispersal in aquatic systems. Impoundments on North American river systems have most notably limited upstream dispersal and resulted in the extirpations of many species. It is unknown if unfavorable habitat similarly inhibits dispersal. Piasa Creek is an adventitious stream of the Mississippi River that possesses a relatively expansive river-tributary interface near its confluence. One hundred sixty-seven collections made over the past 30 years have shown that *Campostoma anomalum* (Cyprinidae) is one of the most abundant species in the drainage. However, there has not been a single specimen collected within the lowermost reaches of the main channel. The lower reaches are characterized by low-gradient, heavily-silted, suboptimal habitat for *C. anomalum*. The purpose of this study is to use molecular markers to assess intradrainage dispersal rates for *C. anomalum* and the isolating effects of unfavorable habitat. Individuals were collected from 2-3 upstream sites in the main channel and the 2 major tributaries. Dispersal among these tributaries requires passage through unfavorable habitat. Allelic variation at microsatellite loci were then used to estimate the dispersal ability of *C. anomalum* through the zone of suboptimal habitat and characterize population differentiation within the drainage.

SPARKS, JOHN S.; DUNLAP, PAUL V.; *SMITH, W. LEO

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Evolution and diversification of a sexually dimorphic luminescent system in ponyfishes (Teleostei: Leiognathidae), including diagnoses for two new genera

A phylogeny was generated for the Indo-Pacific, coastal, bioluminescent Leiognathidae using 6175 characters from seven mitochondrial genes (16S, COI, ND4, ND5, tRNA-His, tRNA-Ser, tRNA-Leu), two nuclear genes (28S, histone H3), and 15 internal and external morphological features of the light-organ system (LOS; circumesophageal light organ, lateral lining of the gas bladder, transparent flank and opercular skin patches) of the fish. The recovered pattern of relationships reveals that, whereas Leiognathidae and two of its three previously recognized genera, *Gazza* and *Secutor*, are monophyletic, the third genus, *Leiognathus*, is paraphyletic. Two new genera are diagnosed on the basis of apomorphic features of the LOS. The results of this combined molecular and morphological analysis suggest that a comparatively simple non-dimorphic light organ gave rise to a complex LOS exhibiting species-specific morphology and a pronounced sexual-dimorphism. Furthermore, this analysis reveals that five distinct and highly specialized morphologies for male-specific or male-enhanced lateral bioluminescent signaling have evolved in these outwardly conservative fishes. The evident morphological patterns of the LOS, in the context of the family-level phylogenetic reconstruction, provide compelling evidence for an assortative mating system in which males use species-specific patterns of lateral bioluminescence signaling to attract mates. This signaling system apparently functions to maintain reproductive isolation in turbid coastal environments.

***SPARKS, JOHN S.; SMITH, WM. LEO**

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Origin of Madagascar's freshwater fishes: A case of dispersing continents

The origins of Madagascar's extant vertebrate lineages have been described as "one of the greatest unsolved mysteries of natural history". Modern phylogenetic evidence congruent with the conventional hypothesis of Gondwanan fragmentation has not been reported for Madagascar's extant terrestrial vertebrate groups. Given a near complete absence of fossil evidence, paleontologists argue that Madagascar's extant and recently extinct vertebrate faunas (including freshwater fishes) owe their origins to Cenozoic colonization via oceanic dispersal. To examine the origins of Madagascar's freshwater fishes, phylogenies have been generated for all major fish clades (catfishes, aplocheiloid killifishes, poeciliids, bedotiid rainbowfishes, non-bedotiid atheriniforms, cichlids, and toadfishes) with members on Madagascar that exhibit a broad Gondwanan distribution (i.e., that can be used to test a Gondwanan vicariance scenario). With one exception, the recovered patterns are congruent with the temporal sequence of Gondwanan fragmentation and suggest that Madagascar's

freshwater fishes owe their origin to the break up of the southern supercontinent, not Cenozoic intercontinental marine dispersal. Only a single sister-group relationship is recovered between a Malagasy and African lineage (landmasses isolated for ca. 165 Myr by at most 430 km). On the contrary, the closest relatives to all other Malagasy freshwater fish clades are present on Gondwanan landmasses (e.g., granitic Seychelles, India, Australia) separated from Madagascar by thousands of kilometers of open ocean since the Early Cenozoic. In light of phylogenetic pattern and geophysical evidence, vicariance is the most parsimonious explanation for the observed biogeographic disjunctions.

***SPENCER, CAROL L.; TRUEB, LINDA; WAKE, DAVID B.**

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Use of HerpNet data for ecological niche modeling research

The importance of museums and their collections to the study of biodiversity cannot be overstated. The data associated with these collections provide keys to the understanding and solution of a diversity of issues. The HerpNet database (www.herpNet.org) combines amphibian and reptile museum databases from 40 institutions throughout the United States, Mexico and Canada. This includes more than 3.5 million specimen-data records representing more than 650,000 unique localities in 202 different countries worldwide. This centrally distributed database provides georeferenced species occurrence data for every specimen housed in these collections. These species occurrence data are critical for GIS mapping applications and ecological niche modeling. Species distributions produced from HerpNet data can be mapped onto climate and habitat layers to predict ecological niches using different models (Bioclim, Domain, GARP, GRASP). These models can then be used for a variety of purposes (e.g. to verify that museum data are correctly georeferenced or if species identifications should be checked, to determine regions where further collections should be made or where previously undiscovered species may occur, to predict areas where climate change may affect species occurrences, or to examine which factors may lead to population extirpation). Using *Phrynosoma coronatum*, *Crotalus atrox* and plethodontid salamander distributions in GIS, we will illustrate how HerpNet data can be used for ecological niche models. Most of the georeferenced data available now on HerpNet include areas in the western United States. All HerpNet museum data for North America are being georeferenced currently and will be made available by 2007, with more data being made available as the project progresses. HerpNet is an invaluable tool that can be utilized easily by herpetologists, conservation biologists, and museum scientists for biodiversity and GIS research.

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HerpNET.org: An online distributed database of amphibian and reptile museum collections

HerpNET (www.herpnet.org) is a collaboration that combines amphibian and reptile museum databases from 40 institutions in the United States, Mexico and Canada. The main goals of the project are to georeference, or assign coordinates to, all localities from these collections using a consistent method, to make these databases available online with mapping capabilities, and to involve more international collections. Each institution has a DiGIR (Distributed Generic Information Retrieval) Server installed that allows a copy of their database to relay information to a main data portal. Any person can query the portal online for information about specific taxa or geographic regions of interest and receive a dataset that can be downloaded as a text file and imported into a spread-sheet format. This contains information about the museum name and catalog number, the species name, the geographic locality, the preparation type, as well as the latitude and longitude. As of April 2005, fifteen museums have their database servers available online through the HerpNET portal; ten more will be online by the end of 2005. Georeferenced data can be mapped on the portal using Berkeley Mapper. The mapping capabilities are flexible, with a number of interactive features (e.g. points can be labeled by museum, errors can be shown around locality coordinates, distances can be measured, the type of background map can be changed to topographic, political boundaries or satellite imagery, and the map can be exported for print or for use in other documents). These data can be used to determine species distributions, to determine which museums have collections in areas of interests, and for use in niche-modeling research to determine the climatic variables associated with species ranges. HerpNET is a valuable tool for herpetologists, conservation biologists, and museum scientists, and we encourage interested museums worldwide to inquire about joining our network.

***SPINKS, PHILLIP Q.; SHAFFER, H. BRADLEY**

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Turtle soup: Delimiting species boundaries and determining species validity in the Asian box turtles (Genus *Cuora*: Family Geoemydidae).

Asian box turtles (genus *Cuora*, family Geoemydidae) are a clade of 12 aquatic and semi aquatic species distributed across China and southeast Asia. Over the last two decades, turtles throughout Asia have been harvested at an unsustainable rate to satisfy demands for food, traditional Chinese medicine, and the pet trade. Consequently, all species of *Cuora* were recently placed on the IUCN Red List, and six are critically endangered. During this same timeframe, a series of geoemydid species were described from specimens culled from market samples. At least five of these are now thought to be hybrids, calling into question the validity of other, recently-described geoemydid taxa. In particular, *Cuora zhoui* and *C. mccordi* were also described recently from market specimens,

and may be hybrids as well. We compiled a 73-specimen combined mitochondrial and nuclear DNA data set to reconstruct the phylogeny of *Cuora* species, and to assess genetic diversity within taxa. Our sampling included 25 *C. trifasciata*, 16 *C. zhoui* and 1-4 individuals of the remaining 10 species of *Cuora*. Maximum parsimony, maximum likelihood and Bayesian analyses all recovered similar well resolved trees. Within the *Cuora* clade, mitochondrial and nuclear sequence data indicated that both *C. zhoui* and *C. mccordi* represent old lineages with little or no history of gene flow. *Cuora trifasciata* was composed of two highly divergent clades that were not each other's closest relatives. One of these clades is paraphyletic with respect to *C. aurocapitata* and *C. pani*, implying that the latter two species may be either invalid or of very recent ancestry. The other lineage of *C. trifasciata* may represent an additional cryptic species, based on both mitochondrial and nuclear data.

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Repatriation of the Tarahumara Frog (*Rana tarahumarae*) to Arizona

Tarahumara frogs (*Rana tarahumarae*) began declining in the late 1970s and continued to decline into the early 1980s. The last wild *R. tarahumarae* in Arizona was found dead in Big Casa Blanca Canyon, Santa Cruz County in May 1983. However, the species is still well-represented in the majority of its range in the northern Sierra Madre Occidental and adjacent sky islands of Sonora and Chihuahua. *Rana tarahumarae* is not federally listed, but is considered wildlife of special concern by the state of Arizona. Plans to repatriate *R. tarahumarae* in Arizona were initiated in 1992 and have been coordinated by the Tarahumara Frog Conservation Team. Stock for release was collected from Sonora, Mexico and reared in captivity. Initial releases to Big Casa Blanca Canyon began in June 2004. This historical site was chosen because of its remoteness and habitat quality. During 4 separate trips, we released 95 adults, 182 juveniles and 328 tadpoles to 3 areas of the canyon. We are using visual encounter surveys to document five stages of success that evaluate the efficacy of this repatriation. To date, we have seen a reasonably high percentage of individuals survive in the short-term (stage 1 success) and possible reproduction (stage 4 success). During the coming year, we will field test our monitoring design and hopefully document additional stages of success (over-winter survival, long-term survival, and recruitment). If successful there, releases of *R. tarahumarae* will also be considered at other historical localities in Arizona.

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**An evaluation of three aquatic sampling techniques for amphibians:
Implications for inventory and monitoring project design**

In response to global declines and threats to amphibian populations, the US government implemented the national Amphibian Research and Monitoring Initiative (ARMI). The ARMI goal is to inventory and monitor amphibian populations on federal lands and to evaluate potential causes of declines. An important component of this effort is to develop efficient sampling techniques for the diversity of amphibian types. I compare the aquatic sampling techniques most frequently used by Southeastern ARMI to evaluate their efficacy in terms of detection and effort, and to identify biases associated with their use. I present data collected during inventories at four USFWS national wildlife refuges: St. Marks, FL, Okefenokee, FL and GA, Harris Neck, GA, and Savannah, GA and SC. Detection probabilities, calculated from data gathered during these inventories, will be used to develop population monitoring protocols. Time constrained dip-net surveys, aquatic funnel traps (modified crayfish traps), and automated frog call data loggers have been regularly used to sample amphibians at the refuges. Twenty-seven species (18 anurans, nine caudates) have been detected using these techniques. Eighty-nine percent of the 27 species were detected during dip-net surveys, 67% in crayfish traps, and 63% with automated call loggers. Species composition differed with each technique, both within and between refuges, as did number of captures and life stages observed. Dip-net surveys and automated call loggers detected more anuran species (17 each) than did crayfish traps (12). Similar numbers of caudate species were found during dip-net surveys (seven) and with crayfish traps (six); these species cannot be detected using automated call loggers. Large aquatic salamanders were captured almost exclusively in crayfish traps. Detectability is influenced by many factors including habitat complexity, environmental conditions, and capture biases. Biases are discussed, as is further research to identify and quantify the sources of variability in detection.

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Experimental evidence of female choice in Lake Malawi cichlids

To date, most research on sexual selection has focused on the discrimination between attributes of individuals of the opposite sex. We have demonstrated female discrimination of a male behavioral character, bower size, by experimentally manipulating bower height in a lek of cichlid fishes from Lake Malawi, Africa. Eggs increased significantly ($p < 0.01$) with large (15 cm) and extra large (30 cm) artificial bowers. Males with extra large bowers received a 50% greater increase in eggs laid than those with just large bowers.

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Movements of eastern mud turtles inhabiting a seasonally inundated wetland

From 2002-2005, we recorded 177 Eastern Mud Turtle, *Kinosternon subrubrum*, captures at a drift fence surrounding a 0.56 ha seasonally inundated wetland in southwest Georgia. The 19 individual adult males were recaptured an average of 3.5 times and 19 individual adult females were recaptured an average of 3.4 times, suggesting relatively equal movements between the sexes. Activity for juveniles, males, and females peaked in March, April and May, respectively. Males, females and juveniles did not enter the wetland in a significantly different direction than they exited as revealed by a Watson-Williams F test ($P = 0.17$; $P = 0.25$; $P = 0.07$). When movement data (entering vs. exiting) was combined, males and females traveled in significantly different directions (216° vs. 281° , respectively, $P = 0.001$). Juveniles did not travel in a significantly different direction than males (212° , $P = 0.845$) but did from females ($P = 0.003$), suggesting that their motives for undertaking terrestrial movements may differ and they respond to different habitat cues. Nesting migrations, a sex-specific activity, may require female turtles to undertake movements into areas not typically utilized by males or juveniles. This research suggests that mud turtles may incorporate a variety of habitat types surrounding wetlands into their life cycle and natural migration patterns should be investigated before development is considered.

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High resolution analysis of yellowcheek darter population structure using AFLPs

The yellowcheek darter (*Etheostoma moorei*) is one of two endemic species among the twenty four darter species found in Arkansas. *Etheostoma moorei* is currently restricted to four headwater systems above Greers Ferry Reservoir on the Little Red River in north-central Arkansas. The filling of the lake in 1962 inundated much of the historical habitat of this species and effectively isolated each of the four remaining populations to the Middle, South, Archey, and Turkey Forks. Furthermore, these populations have experienced a drastic reduction in numbers due to reduced flow in these streams over the last 20 years. The development of a captive breeding program has fostered a demand for knowledge of each remaining population. Hydrologic studies have identified differences among the stream habitat of each system including flow, gradient, and substrate particle size. Life history studies have noted differences among populations in diet, reproductive season, and growth. Allozyme analysis has demonstrated significant differences among populations of the four stream systems, yet not within streams. DNA fingerprinting techniques such as amplified fragment length polymorphism (AFLP) use nuclear genomic markers to identify polymorphisms within the genome of an organism. AFLP's have been shown to

elute differences within and among plant and animal populations on a fine-scale. Genetic differences were identified between yellowcheek darters of separate sites within streams and even those occupying different riffles of the same site in the present study.

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The evolution of trade-offs in the locomotor performance of emydid turtles

Within many groups of organisms, different species are specialized for different ecological tasks and settings. Organisms are thought to specialize to improve their performance at a given task, even though this may result in decreased performance at another task. How and why this process of specialization occurs lies at the intersection of the fields of evolutionary biology and ecology, and yet tradeoffs in performance have rarely been examined using a phylogenetic approach (which is necessary to identify the direction of evolutionary change and of specialization). Only if increased performance in one setting is associated with a decrease in performance in another setting compared to the ancestral condition does it represent a true trade-off. Emydidea is a family of turtles that includes aquatic, terrestrial, and semi-terrestrial species. The diverse habitats these species inhabit (presumably) have very different requirements for locomotion. To investigate trade-offs during the evolution of emydid locomotor performance a series of trials were performed in which the aquatic speed, terrestrial speed, and endurance of 16 emydid species were measured. Reconstruction of the performance of hypothetical ancestors showed that there have been "true" evolutionary trade-offs in the locomotor performance of emydid, but that the nature of these trade-offs is somewhat surprising.

***STEPIEN, CAROL A.; STRANGE, REX M.**

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Population genetic structure and geographic patterns of smallmouth bass in the Great Lakes

Patterns of genetic variation, stocks, and phylogeographic structure of smallmouth bass *Micropterus dolomieu* (Centrarchidae) are analyzed throughout the Great Lakes and their native North American range, with particular concentration in Lake Erie. We test allelic variation at eight nuclear microsatellite DNA loci for 500+ samples, including 10 sites in Lake Erie encompassing the west, central, and east basins and several rivers; Lake Superior, Lake Huron, Lake Ontario, and the Ohio and Mississippi River drainages. Significant differences are revealed among spawning groups, basins, lakes, and rivers - with greatest difference among groups that diverged in separate glacial refugia and in non-glaciated areas, congruent with vicariant phylogeography predictions. Some populations within the Lake Erie drainage show significant differences between lake versus nearby tributary populations. Results are consistent with known

migratory patterns and reproductive behavior of smallmouth bass. These phylogeographic population structure patterns likely were enhanced by philopatry to spawning and natal localities. Integrating these data analyses showing spatial arrangement of genetic variation with fishery management practices will aid the preservation of genetic identity and variation of populations and fishery stocks in the Great Lakes.

***STEPIEN, CAROL A.; STRANGE, REX M.**

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DNA identification of yellow perch fillets from a fish fry: Is the fish on your menu local?

Identifying species of fish from restaurants and fish markets is a growing problem, as one may not be eating what one reads on a menu. DNA sequence tools offer a fast and highly reliable solution, albeit about 5 times more expensive than your typical fish fry. Our Great Lakes Genetics Laboratory was given 5 samples of fish from 5 different restaurants in a single large city on the Great Lakes, as unknowns from a local TV news agency. The fish on the menu were called lake perch. In each case, the samples were breaded and deep-fried. We removed the breading and extracted the DNA. We note that we were initially unsure whether we could successfully extract DNA that had been deep-fried. A portion of the mitochondrial DNA cytochrome b gene was amplified using the polymerase chain reaction (PCR) and sequenced. Results showed that three of the samples were indeed yellow perch *Perca flavescens* from the Great Lakes, and two were Eurasian yellow perch *Perca fluviatilis*. Results thus demonstrate that putatively local yellow perch on our Great Lakes menus may not be local, but from overseas.

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Population genetic structure of yellow perch in the Great Lakes: A comparison with eastern North American populations

The present study analyzed the population genetic structure of the yellow perch *Perca flavescens* (Percidae) using DNA sequence data from the entire mitochondrial DNA control region (912 base pairs) and several nuclear microsatellite loci of spawning individuals from Lake Erie. Comparisons of genetic diversity and phylogeographic divergence patterns were made among population samples from Minnesota, Lake Ontario, Maine, North Carolina, and Georgia. The data reveal a widespread haplotype of yellow perch in the Great Lakes region, comprising 80% of the individuals and indicating relatively low genetic diversity. Greater diversity was discerned with the microsatellites. A total of eleven mtDNA haplotypes were identified from Lake Erie, in comparison with 2 in Minnesota, 2 in Lake Ontario, 3 in Maine, 2 in North Carolina, and a single haplotype in Georgia. Both data sets revealed significant genetic

divergences among samples for some spawning sites in Lake Erie, among Lakes, as well as long-term pronounced divergence between the Great Lakes region (including Minnesota) versus the eastern population sites. The latter suggests an early Pleistocene separation. Analysis of yellow perch population genetic structure and variation across the native range may provide a management tool for understanding genetic diversity, as well as help to interpret the phylogeographic history of these populations.

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Fish community change in a Susquehanna headwater: Effects of predation and invasions

Fish communities in East Branch of Owego Creek, a Susquehanna basin headwater in south-central NY, were extensively studied in the 1960s [by A. Sheldon], and those samples provide a solid basis for evaluating subsequent changes. In that initial sampling, 115 sites were blocked and electro-fished, yielding over 17,000 fishes. In 2003-04, we re-sampled that same area with blocking seines and electro-shockers, collecting about 7,000 fishes at 39 sites. Our primary objectives were to evaluate fish community change over that time period and to consider possible causes for any observed changes. Changes in community patterns were analyzed using detrended correspondence analysis [DCA] of the species by locality matrix [$\log(x+1)$ transformed abundance data]. Results indicate that first and second order tributaries have had very little community change; whereas, slightly further downstream in third-order segments, there have been dramatic changes. Third order sites closest to the headwaters now have fish assemblages resembling those farther upstream because pool-dwelling minnows have been greatly diminished [e.g., previously abundant common shiners, stonerollers and redbreast dace are now absent]. Moving a few km farther downstream, the creek widens, deepens and vegetated backwaters add to habitat diversity. In those segments, community change involves decline or loss of several minnows and northern hog suckers. Those species declines are balanced, in part, by the addition of species not observed in the 1960s, including banded darter and greenside darter, so overall species richness has not changed noticeably. Evaluation of possible causes for such changes leads us to infer that predation by brown trout may have been an important factor in declines of minnows and hog suckers. In vegetated backwaters, formerly abundant banded killifish are now absent and, apparently, replaced by brook stickleback; we speculate that change could be related to arrival of exotic rock bass. We suggest that trout stocking policies may need to explicitly consider possible effects on native minnow assemblages.

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Reproductive characteristics of the long-tailed spiny lizard, *Sceloporus siniferus* (Sauria: Phrynosomatidae) from Huatulco, Mexico

Ecological studies are important for organismic conservation and by extrapolating endogenous as well as exogenous factors, the regulation of reproductive strategies can be outlined. *Sceloporus siniferus*, a relatively unstudied tropical lizard, was examined to determine male and female reproductive timing; seasonal variation; pinpoint organism reproductive dependence; as well as deduce specific environmental factors to maximize reproductive output. The hypothesis was that maximal reproduction would occur during the wet season located between May and December. In Huatulco, Mexico, 78 males and 45 females were analyzed with the employment of elastic shooting and noosing methodology. General morphological features were measured, along with internal fat weight (g) and reproductive organs in both sexes. Male reproductive output was supplemented with histological sections for comprehensive analyses. Though an inclusive examination, *Sceloporus siniferus* was shown to suggest a dual reproductive clutch during maximal rainfall. Male and female reproduction was observed as being associative, peaking in the beginning of the wet season and again at the end of the wet season, with the later being less prolific in offspring production. Females were observed to retain ova in the months between maximal reproductive peaks, while males were shown to contain a spermatogenesis refractory period. In both male and female *Sceloporus siniferus*, fat reserves were utilized during the first reproductive peak and not the second. Furthermore, body weight was observed to be the most significant influential factor in determining maximal reproduction, as seen with most smaller-bodied, multiple-clutch, tropical lizard species. *Sceloporus siniferus* was also shown to increase reproductive output during times of elevated temperature and precipitation; however, precipitation was in fact illustrated as being the ultimate cue for reproduction in this species, supporting hypotheses. The influence of these exogenous factors on the reproduction of *S. siniferus* may also have played a role in annual variance from 2000 to 2004. **STORER**
HERPETOLOGY

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Watersnakes (*Nerodia*) in California: Different fates for two introduced species

Among squamates, preliminary evidence indicates that snakes are generally less effective invaders than lizards, and among snakes, Natricines may more readily establish than some other groups. Two watersnake species (*Nerodia*) have recently established extralimital populations in California. *Nerodia rhombifer* reached high densities at an isolated reservoir in the late 1980's, flourished to the point of causing distress for land managers, and underwent a massive die-off in

the late 1990's, apparently due to an unidentified pathogen. Watersnakes are occasionally still reported from the reservoir, but none have been confirmed since 1999. *Nerodia fasciata* was first reported from northern Sacramento in 1992. Despite an ongoing eradication program, the species still persists and is an established part of California's herpetofauna. We argue that species attributes, combined with severely altered landscape and habitat conditions, predisposed these snakes to successfully establish; however, we lack evidence that these introductions had negative effects on the already altered ecosystems. In more fragile aquatic systems such as vernal pool complexes or native fish refuges, introductions of *Nerodia* and related snakes might be immediate and severe. We suggest that synthetic studies be undertaken to determine correlates of successful snake introductions, and suspect that correlates of invasive snakes will differ from those of other invasive herpetofauna. Future research may find relationships with aquatic habitat use, generalist habitat selection and dietary preferences, and reproductive traits, including high fecundity and viviparity. Knowledge of such correlations can be applied by wildlife regulatory agencies to develop management guidelines and species watch lists to prevent future introductions or implement eradication strategies.

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Population-level variation of tiger salamanders in proteomic responses to iridovirus infection

Infectious diseases have been implicated in the global decline of amphibians, and iridoviruses, in particular, are the cause widespread epizootics of tiger salamanders throughout western North America. In a laboratory experiment, we investigated interpopulational variation in cellular responses of tiger salamanders (*Ambystoma tigrinum*) to *Ambystoma tigrinum* virus (ATV). We exposed two groups of salamanders to a lethal dose of ATV at 3 months of age: the first group consisted of inbred laboratory salamanders from two families, and the second group contained field-collected animals from two populations. Moribund animals were euthanized and screened using ELISA and SDS-PAGE western blotting for the following protein metabolites associated with stress and immune responses: heat shock proteins 60, 72, 90 and small heat shock proteins, Cu-Zn superoxide dismutase, ferrochelatase, protein carbonyl, heme oxygenase and ubiquitin. All cellular parameters were significantly upregulated in infected versus uninfected animals with the exception of heme oxygenase. In addition, salamander populations differed in their cellular responses to ATV infection. Among the laboratory-bred groups, infected and uninfected individuals of *A. t. stebbinsi* (an endangered subspecies with very low genetic variability) did not differ in six of the nine assays (all except Hsp 72, Hsp 90 and protein carbonyl). In contrast, infected animals of laboratory-bred *A. t. nebulosum* (a widespread and genetically variable species) had significant upregulation of cellular proteins in five of nine assays and mean ferrochelatase and small heat shock protein

accumulations 5-41 times greater than in *A. t. stebbinsi*. For most assays, infected wild-caught animals had significantly higher levels of cellular proteins than infected animals from inbred lines. Individuals from the two wild-caught populations also differed significantly in some cellular responses. Overall, variability in the intensity of the cellular response seems to be correlated genetic variability in the source population. These results suggest that effects of ATV will not be consistent among *A. tigrinum* populations due to variability in cellular repair responses to the pathogen.

***STRANGE, REX MEADE; LAWRENCE, KAREN A.**

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Histological adaptations and positive directional selection of rhodopsin genes played a role in the evolution of percid visual systems

Percid fishes represent an ideal group in which to examine the process of adaptation to different photic environments. Representatives of the family occupy a variety of habitats, ranging from turbid lacustrine and river habitats (Luciopercinae and Percinae) to shallow headwater streams with almost complete spectral transmission (Etheostomatinae). Turbid water represents an extreme environment for these visual predators because suspended particles reduce the quantity of available light and alters its spectral quality. Although retinal structure optimized for light sensitivity is a common adaptation to dark environments, it is unknown whether such histological structures are matched at the molecular level by changes in the spectral sensitivity of opsin proteins. We examined differences in retinal structure and rhodopsin sequence divergences among representative percid fishes for evidence of correlated adaptations to different photic environments. Retinal structure in Luciopercinae and Percinae is optimized for low levels of ambient light, with *Sander* species exemplifying the most extreme form. Darters (Etheostomatinae) have a generalized retinal structure typical of headwater stream fishes with diurnal activity. Rhodopsin sequence divergences and inferred amino acid translations show more synonymous substitutions than that expected under the expectations of neutral theory. CM analysis revealed evidence of positive directional selection on the rhodopsin gene since the divergence of the darter and Luciopercinae+Percinae clades, with evidence of functional constraint within each clade. Changes at key points in the rhodopsin protein indicate a red shift in the spectral sensitivity in the larger percids relative to the darters, consistent with photic environments marked by high turbidity. Thus, percid fishes exhibit extreme adaptations at the histological and molecular levels that correlate with their behavior and habitat affinities.

***STRANGE, REX MEADE; STEPIEN, CAROL A.**

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Historical biogeography of Walleye (*Sander vitreus*) as inferred from mitochondrial and microsatellite loci

Walleye (*Sander vitreus*) is a large and highly vagile percid fish distributed in both formerly glaciated areas and regions south of the glacial maxima. Most previous genetic studies have focused on stock structure in the Great Lakes, but few attempts have been made to examine the relationships between the northern and southern populations. We examined genetic variation among spawning populations of walleye in the Great Lakes, Ohio River, and Mobile Basins for evidence of geographic structure. Sequence variation at mitochondrial DNA (mtDNA) loci and allelic length variation for 10 microsatellite loci were tested for conformance with expectations of panmixia and Hardy-Weinberg equilibrium. We found that most major spawning sites in the Great Lakes are discernable and readily separable into either eastern or western lakes. This broadscale structure reflects their origin in separate glacial refugia and subsequent isolation of the various spawning populations by distance. Comparisons between walleye from the Great Lakes versus native spawning populations in the Ohio River and Mobile Basin revealed distinctive genotype assemblages and mtDNA haplotypes, related to historical patterns of isolation. Phylogenetic analysis suggests that walleye from the Great Lakes did not originate from an Ohio River refugium. We note that although genetic variation in walleye may have been obscured by stocking efforts resulting in homogenization across its range, unique native populations still exist and should be protected.

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Methods for detecting *Bufo marinus* sex pheromones

A pair of mating cane toad (*B. marinus*) specimens was analyzed in order to detect sex pheromone compounds. Two methods of extraction were utilized. In the first method, carbon-filtered air was drawn over the mating female specimen and continuously condensed in a sealable cold trap for 30 minutes. The cold trap was immersed in a dry ice/acetone bath while air was sampled. HS-GC-MS analysis of the cold trap contents did not detect pheromone compounds. In the second method, solid phase micro extraction (SPME) was employed. The matrix active group for the SMPE was 70 micron carbowax/divinylbenzene. The matrix was exposed to the mating pair for 4 hours. Specimens were kept in a glass container without any soil, substrate, or plants during the sampling period. The air inlet to this container was carbon-filtered. GS-MS analysis of the matrix did not detect pheromone compounds. Urine and skin secretions of mating and non-mating female specimens were collected and analyzed. Urine samples were harvested by holding the specimen over a funnel and collection container. Skin secretions were collected by immersing the specimen in HPLC-grade water for 1 hour. A spectral comparison of skin and urine samples from 200nm to 800nm both produced the same characteristic absorbances in the 200nm to 300nm range. The peak absorbance for skin samples occurred at 216nm. The peak absorbance

for urine samples occurred at 260nm. Stronger absorbances were observed in the urine sample than the skin secretion samples. Cold traps using liquid nitrogen and SPME using other active matrices are planned for future studies.

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An improved qualitative method for detecting and isolating shark-repelling semiochemicals

We have developed an improved qualitative method for detecting and isolating shark-repelling semiochemicals utilizing reverse-phase liquid chromatography and gradient elution. The method employs a reverse-phase column and acetic acid gradient with spectral detection range between 240nm to 340nm. Samples are deproteinized using perchloric acid, neutralized with potassium hydroxide, centrifuged, and filtered prior to injection into the column. Two groups of early eluting (less than 6 minutes) and very late eluting (greater than 25 minutes) peaks characterize the compound of interest. Degradation of the semiochemical from heat or inadequate storage is a recurrent problem and is readily evaluated by observing the areas under these characteristic peaks. Compounds which have been shown to lose efficacy in field trials reveal the absence of certain characteristic peaks when using this qualitative method. We used the same method reverse-phase to observe primary and secondary amines in the semiochemical extract using derivatization with w/w ninhydrin, pre-column. Derivatized samples were allowed to develop color for 1 hour prior to injection with detection for secondary amines at 440nm while that for primary amines was at 570nm. Comparison of the spectra for extracts from *Carcharodon carcharias*, *Negaprion brevirostris*, *Carcharhinus limbatus*, *Ginglymostoma cirratum*, *Squalus cubensis*, *Galeocerdo cuvier*, and *Dasyatis americana* between 200nm to 800nm show absorption commonalities. The greatest absorptions were found in extracts from the head of *C. carcharias*. A 500ml sample of head extract from *C. carcharias* was tested for repellency on six *C. perezii* and two *C. acronotus*. Sharks were attracted to the test site using fish heads and chum, and a 500ml seawater control was delivered. The control did not affect feeding behavior. When 500ml of the head extract was presented, *C. perezii* and *C. acronotus* displayed aversive behavior within 2 minutes of dosage. Both *C. acronotus* subjects departed visual range and four of six *C. perezii* subjects departed visual range. The remaining two *C. perezii* were disinterested in food for the next 10 minutes.

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Effects of magnetic fields exceeding 50 Gauss on tonically immobilized sharks

Sharks are well known to detect electric and magnetic fields from the work of

Kalmijn, Tricas, Klimley and others yet there is still controversy as to the mechanism of magnetic field detection. To evaluate the potential of strong magnetic fields as a repellent we exposed three species of sharks to rare earth magnets. We observed that magnetic fields exceeding 50 Gauss terminated tonic immobility (TI) in juvenile lemon sharks, *Negaprion brevirostris*, nearly adult blacktip sharks, *Carcharhinus limbatus*, and juvenile nurse sharks, *Ginglymostoma cirratum*. Grade N48 and N50 nickel coated, permanent, neodymium-iron-boride magnets with a residual induction of 1 Tesla (10,000 gauss) were utilized in a series of trials. These magnets were 100 mm diameter cylinders with a 25 mm height. A digital gauss meter was used to measure the strength of the magnetic field relative to the experimental subject. In one series of trials, immobilized sharks were held stationary relative to the magnet's axial (flat) face and the magnet moved toward the shark. In a second series, tonically immobilized sharks were moved relative to the stationary magnet. In both series, immobilized sharks awakened from tonic immobility at a distance of between 10 and 20 cm from the magnet's face. Sharks were positioned both axially (nose-first) and laterally (eye-first) to the magnet. Tonically immobilized sharks turned away from the magnet, despite the direction of the approaching magnetic field. In a separate set of trials, two 12 volt DC-powered electromagnets, 75W and 360W with magnetic fields of approximately 2 gauss and 20 gauss respectively, failed to terminate TI even at distances less than 1 cm from the shark. Attempts were made to shield the sharks by blocking the magnetic field using mu-metal and bismuth metal covers. Both 12.5 mm thick folded Mu-metal foil and a bismuth metal block were apparently ineffective at shielding the magnetic field and did not inhibit a shark's response. We noted that diamagnetic bismuth metal alone will occasionally terminate tonic immobility at a range of 10 cm or less.

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The role of isolated, seasonal wetlands in the ecology of the American Alligator

Connectivity of isolated, seasonal wetlands is facilitated by movements of species which inhabit them. Understanding how species use these seasonally fluctuating environments and how they disperse across the landscape is thus important to understanding and conserving both the habitat and the species. Results from three summers of mark-recapture work on American alligators (*Alligator mississippiensis*) at the Joseph W. Jones Ecological Research Center in southwest Georgia indicate alligators use isolated, seasonal wetlands as nesting and nursery sites. 88% of the alligators captured in wetlands are juveniles (less than 60 cm snout-vent length), and we have located three active alligator nests near wetland edges. However, while these wetlands provide good habitat for juveniles, they probably are unable to support many adults. We hypothesize that subadult and adult alligators in this population disperse between the seasonal wetlands and nearby riverine systems. Alligators are known to experience a marked ontogenetic shift in diet and habitat, and their habitat use and dispersal should vary among different size classes. We will continue to study habitat use and nesting in the same population of alligators to determine which size classes are using different habitat types and for what functions. We will study dispersal

patterns of different size classes using mark-recapture and radio telemetry. We will also study whether wetland isolation and hydroperiod influence the probability of occupancy of a wetland by alligators. Understanding how inland populations of alligators use seasonal wetlands and the surrounding landscape will identify the multiple habitat types that are probably important to the conservation of a single population.

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Stable isotopes reveal two carbon sources in the Northern Gulf of Mexico deep reef fish community

Analysis of ^{13}C and ^{15}N stable isotope signatures were conducted for 1255 samples representing carbon sources and 107 taxa of fishes and invertebrates comprising the surface to substrate ecosystem of the outer continental shelf in the northeastern Gulf of Mexico. Research focused on the deep-reef community of the Pinnacles reef tract, testing the null hypothesis that carbon fixed by oceanic phytoplankton is the only carbon source sustaining the community. The single carbon source paradigm is the standard paradigm for the open ocean worldwide. Results revealed no evidence in fish muscle tissue or invertebrate soft tissue of input of terrestrial carbon ($\delta^{13}\text{C} > +25$) into the offshore food chain. Neither was evidence found of highly negative signatures ($\delta^{13}\text{C} < -25$) for carbon derived from chemoautotrophs (vent/seep animals). However, substantial evidence of dual carbon sources was demonstrated in consumer tissue carbon signatures based on phytoplankton ($\delta^{13}\text{C} = 19.3$) and others based on Sargassum ($\delta^{13}\text{C} = 15.9$). Sediments showed plankton-derived carbon values ($\delta^{13}\text{C} = 19.8$). The plankton-based food chain includes fish planktivores, epipelagic and benthic intermediate level predators and omnivores, and apex macrovores; $\delta^{15}\text{N}$ data reveal a short food chain length of 4.2 o/oo ($\delta^{15}\text{N}$ range = 8.6 to 13.4 o/oo), resolved into 2.2 consumer levels. Mean $\delta^{13}\text{C}$ per trophic level = 1.93 o/oo. The Sargassum-based food chain includes epipelagic Sargassum associates, epipelagic intermediate consumers, benthic particulate-feeding invertebrates, deposit feeders, benthic macrovores, and apex predators; $\delta^{15}\text{N}$ data reveal a food chain length of 8.3 o/oo ($\delta^{15}\text{N}$ range = 4.7 to 13.4 o/oo), resolved into 4.3 consumer levels. The null hypothesis, the single plankton carbon source paradigm, is refuted by this study, which demonstrates that Sargassum macroalga derived carbon is important to the deep-reef community of the outer continental shelf.

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The reproductive cycle of the smooth skate, *Malacoraja senta*, in the western Gulf of Maine

The smooth skate (*Malacoraja senta*) is common to the waters of the western north Atlantic, ranging from the St. Lawrence River south to George's Bank. To date, very little biological data has been collected for this species, leaving many questions unanswered. Furthermore, recent stock assessments in the Gulf of Maine indicate the biomass of smooth skates has declined below threshold levels mandated by the Sustainable Fisheries Act. Thus, the synergistic lack of biological data and overall population decline has prompted the National Marine Fisheries Service to prohibit the possession of this species in this region. As part of a large study goaled at documenting life history parameters of *M. senta*, the present study describes and characterizes the reproductive cycle of female and male smooth skates, based on monthly samples taken off the coast of New Hampshire, USA, from May 2001 to April 2002. Gonadosomatic index (GSI), hepatosomatic index (HSI), shell gland weight, follicle size and egg case formation, were assessed for 79 female skates. In general, these parameters remained relatively constant throughout most of the year, with the exception of a transient increase ($p < 0.05$) in GSI in August. Moreover, developing or fully developed egg cases were observed in the uteri of specimens captured in seven out of the twelve sampling months. For males (N=81), histological stages III through VI (SIII-SVI) of spermatogenesis, GSI and HSI were examined. No significant differences were found throughout the year for any parameter. However, the production and maintenance of mature spermatocysts (SVI) were observed within the testes throughout the year. Based on these observations, it appears as though the smooth skate is capable of reproduction year round.

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Determination of age and size at sexual maturity for the thorny skate, *Amblyraja radiata*, using morphological, histological and steroid hormone analyses

The thorny skate (*Amblyraja radiata*) is a large species of skate that is endemic to the waters of the western north Atlantic. Current stock assessments in the northeast U.S. indicate the biomass of *A. radiata* is below threshold levels mandated by the Sustainable Fisheries Act. Due to this circumstance, commercial

harvest of this species is now prohibited from this region. In order to gain insight into the life history of this skate from the western Gulf of Maine, age at size was linked to maturity by using criteria from three endpoints; steroid hormone concentrations, gross morphological examination of reproductive tracts and histological examination of spermatogenesis. Age bias plots and the coefficient of variation, from vertebral band counts, suggests that our ageing method represents a non-biased and precise approach to the age assessment of *A. radiata*. Maturity ogives for males (n=67), predict that 50% maturity occurs at a total length of 875 mm and at 11 years. For females (n=69), maturity ogives predict that 50% maturity occurs at a total length of 865 mm and 11 years of age. Collectively, our results suggest that analyzing a combination of reproductive parameters offers an accurate determination of sexual maturity in the thorny skate. An additional outcome of the present research is that analysis of circulating hormone concentrations (a relatively non-invasive approach, i.e. without sacrificing the skate) provides an accurate means to determine size at sexual maturity.

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Growing the tree of catfish life in the fertile garden of ACSI

In addition to its all-species goal, the All Catfish Species Inventory (ACSI) is promoting reconstruction of the phylogeny of siluriform higher taxa into which an anticipated 4,000+ species can be placed. Catfishes form a profusely and divergently branched limb in the tree of life. About 1 in 4 valid species of freshwater fishes, 1 in 10 fishes, and 1 in 20 vertebrates, is a catfish. The exceptional diversity of catfishes is reflected by their classification into some 450 genera and 34 families. Yet the major phylogenetic lines of Siluriformes are partially and unevenly resolved. Morphological data strongly indicate that South American Diplomystidae are sister to all other catfishes (siluroids), and fossil North American Hypsidoridae are a deep clade subtending the remaining siluroid catfishes. Also, Neotropical Cetopsidae have been proposed as relatively basal catfishes. The many remaining catfishes are in about 31 well supported, monophyletic families, but few multi-family groups: loricarioids (Nematogenyidae, Trichomycteridae, Callichthyidae, Scoloplacidae, Astroblepidae, Loricariidae); sisoroids (Akysidae, Amblycipitidae, Erethistidae, Sisoridae, Aspredinidae); doradoids (Mochokidae, Doradidae, Auchenipteridae); Amphiliidae, Pseudopimelodidae, Heptapteridae, Pimelodidae, Ariidae, Clariidae, Schilbidae, Pangasiidae, Claroteidae, Malapteruridae, Bagridae, Australoglanididae, Cranoglanididae, Ictaluridae, Siluridae, Chacidae, Plotosidae. Furthermore, some enigmatic genera have controversial or no current familial membership, e.g. *Ancharias*, *Conorhynchos*, and the Chiapas catfish. Here we report the combined results of our analysis of 2670 base pairs of the nuclear RAG1 gene and 750 base pairs of the RAG2 gene for ca. 80 terminal siluriform taxa plus gymnotiform and characiform outgroups. Software-aligned sequences were manually corrected to conform to codons inferred from the amino acid translation, and analyzed using parsimony, maximum likelihood and Bayesian methods. Many but not all morphologically well-characterized catfish clades are

recovered as monophyletic, whereas several novel relationships among groups receive strong and thought provoking support, and disquieting matters of near basal non-resolution of many lineages persist.

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Hot and cold skeletons - the effect of temperature on the properties of cartilage

The chondrichthian skeleton is made of lightly mineralized cartilage. Since the material properties of gels vary with temperature and cartilage is a fiber reinforced gel, we tested whether temperature has an effect on the properties of shark skeletons. The sleeper shark (*Somnoisus pacificus*) typically lives in cold water of the northern Pacific. *Mobula thurstoni* inhabits warmer waters of the central Pacific. Using a small environmental chamber we performed dynamic compressive tests at four temperatures between 4 and 30 degrees C. Cartilage is stiffer at colder temperatures and sleeper shark cartilage is less stiff than *Mobula* cartilage at 30 degrees.

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Morphological heterogeneity in the Green Chromide *Etroplus suratensis* (Pisces: Cichlidae) among six estuaries in Sri Lanka

Fishes are known to display intraspecific morphological variation sometimes to the extent that different geographic populations can be discriminated by their morphology. Morphological variation of the euryhaline cichlid fish *Etroplus suratensis* (Bloch) at six geographically apart estuaries located along the southern and western coasts of Sri Lanka was studied for the presence of morphological heterogeneity. Data collected on fourteen morphometric characters and eleven meristic characters (n=220) were tested. Shape measurements were standardized to remove the size effect. Univariate ANOVA revealed that twelve morphometric and five meristic characters were significantly different (p<0.05) among selected locations indicating heterogeneity in morphology of the cichlid. Concordant results were found by multivariate analysis of the size-corrected morphological data which indicated that the fish from most of the selected estuaries could be distinguished from each other. The first two canonical variables in the discriminant function analysis accounted for 87% of the variance in the data (first 70.6%, second 16.4%). Derived function could correctly classify an average of 81% of the individuals into their *a priori* groups. The pair-wise Mahalanobis distance calculated was not in agreement with the isolation by distance model. The data point to the conclusion that the *E. suratensis* populations in the estuaries studied maintain considerable morphological distinctiveness. This is apparently due to partial isolation at a micro geographic scale, which is also substantiated by the life history of the species.

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Larval fish imitating a bird feather: a unique example of phaneric mimesis in the pelagic environment

Numerous examples of mimicry of inanimate objects are well documented, mainly for the terrestrial realm. The epipelagic ocean, known for its cover-deficient properties, would seem to be less suitable habitat for development of such defensive strategies. Thus, the main tactic, utilized by many planktonic organisms including fish larvae, is to become virtually transparent. Despite recent descriptions of the early life history of the ophidioid genus *Brotulotaenia*, the form-function relationships during early ontogeny of this rare deep-sea species have never been addressed. A recent finding of a larval *B. nielsenii* in nearly perfect condition allowed further observations of its morphology leading to a hypothesis regarding its mimetic resemblance to a bird feather - an apparently new defense strategy in the epipelagic ocean. In this paper I approach the unusual Bauplan of larval *Brotulotaenia* from the functional/morphological standpoint, and show how a suite of larval features facilitates a resemblance to a proposed inanimate model, thus offering a possible protection against visually hunting predators. The numerous similarities between the hypothesized model (bird feather) and the mimic (larval fish), as well as some basic requirements prerequisite for development of such mimicry are reviewed and discussed.

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Inner ear structure and otolith morphology in some common deep-sea eels

Eels represent an important and often very abundant component of deep-sea ichthyofauna. However, the morphology of the inner ear and otoliths of deep-sea anguilliforms received very little attention to date. In addition, otolith information available usually covers the single largest otolith - the sagitta. As part of an ongoing project on age and growth of deep-sea pelagic fishes, we investigated morphology of the semicircular canals and three types of otoliths in some common and abundant deep-sea eels - *Nemichthys scolopaceus*, *Synaphobranchus kaupii*, *Serrivomer beanii*, *Simenchelys parasitica* and *Eurypharynx pelecanoides*. In this study we cover the overall morphology of the saccular, utricular and lagenar otoliths for each of these species as well as basic morphology of the inner ear and its relative position within the otic region of neurocranium. As the form-function relationships between different otoliths and their morphological characteristics are relatively poorly understood, this study was conceived to facilitate future ecomorphological studies of deep-sea fish acoustico-vestibular systems, to help better understand the functional significance and relative importance of different otoliths in various groups, and to relate the enormous variation in the observed otolith morphology to a variety of processes operating in the deep-sea.

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Effects of excessive sedimentation on the stress response, growth rate and gill condition of two southeastern upland minnows, the whitetail shiner (*Cyprinella galactura*) and spotfin chub (*Erimonax monachus*)

Despite the recognition of increased suspended sediment concentration (SSC) as a primary pollutant of streams, research on the effects of SSC on upland non-game fishes is lacking. We investigated the effects of elevated SSC on the stress response (i.e. whole-body cortisol concentration), specific growth rate (i.e. % change in weight per day), and gill condition (i.e. lamellar thickness and interlamellar area) of young-of-year (YOY) whitetail shiners (*Cyprinella galactura*) and federally threatened spotfin chubs (*Erimonax monachus*) exposed to elevated SSC (0, 25, 50, 100 and 500 mg/L). Stress trials were 48 h and growth and gill condition trials were 21 days. Sediment-induced stress response in spotfin chubs was 3-fold higher than controls; this response was similar to that observed in rainbow trout exposed to acute handling stress. Exposure to elevated SSC caused a significant decrease in specific growth rate in both species and at all life stages tested. The impact of sediment was greatest in the youngest fish. The effect of increased SSC was greatest in spotfin chubs, which exhibited a 15-fold decrease in specific growth rate at the highest treatment. When compared to salmonid responses, these minnows exhibited a greater response at low to moderate SSC and a lower response at higher sediment levels. Gill damage was minimal at the three lowest treatment levels, moderate at 100 mg/L and severe at the highest SSC. Respiratory surfaces of spotfin chubs appear to be much more sensitive than other species previously tested. Gill interlamellar area and specific growth rate were both significantly and inversely related to increasing gill lamellar thickness. Even moderate levels of suspended sediment (i.e. 100 mg/L) can severely stress and cause impairment of growth and gill condition of southeastern upland fishes.

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The bathypelagic fish assemblage of the Gulf of Mexico

The open ocean bathypelagic zone (>1000 m) is by far the largest habitat by volume on this planet, yet it is the least explored. Between 1996 and 2000, a deep trawling program was conducted in the eastern Gulf of Mexico (Gulf) for the purpose of studying the bathypelagic community. A total of 46 tows quantitatively sampled discrete depth horizons below 1000 m. These samples contained 93 fish species (two undescribed) from 39 families. Of these, 11 were new Gulf records, and two were new Atlantic records. The family Myctophidae was represented by the most species (13), not including likely mesopelagic

contaminants, followed by the ceratioid anglerfishes (12 spp.), the Stomiidae (10 spp.) and the Gonostomatidae (9 spp.). Species of the genus *Cyclothone* were most prevalent in terms of both numbers and catch frequency, with *C. pallida* and *C. obscura* the most numerous fishes collected. The Platytroctidae was the dominant family in terms of biomass. In comparison to the overlying mesopelagial (200-1000 m), the shift observed in the bathypelagial was both taxonomic (e.g. myctophids and phosichthyids replaced by ceratioids and platytroctids) and ecological (crustacean planktivory replaced by piscivory and gelatinous predation). The latter will be discussed further in detail.

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Gender differences in the habitat preference of eastern box turtles (*Terrapene carolina carolina*) using forests and adjacent tidal wetlands

From 2000 through 2004, we used radio telemetry to study the home range characteristics of 41 box turtles (25 females, 13 males, and 3 juveniles). Our study site encompassed deciduous riparian forest and wetlands along the tidal Patuxent River in central Maryland. Mean female home range size was 6.2 ha, whereas the mean size of male home ranges was only 1.2 ha. Sixteen of 31 female home ranges exceeded 4 ha, and seven female home ranges exceeded 10 ha in size. By tracking the same five females over several seasons we obtained a more accurate estimate because individual home range size can vary considerably from one year to the next. Most females made extensive use of tidal wetlands and managed meadows, whereas males restricted their activities mostly to the forest. Meadows were used primarily for nesting. Females used wetlands for feeding, thermoregulation and probably for restoring moisture that was lost during nesting forays in dry, exposed habitats. Gender differences in home range size and habitat use are not well documented in box turtles, yet alternate strategies by males and females have important conservation and resource management implications.

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A molecular genetic investigation of hybridization between *Etheostoma osburni* and *Etheostoma variatum* in the New River drainage

Etheostoma osburni and *E. variatum* are closely related species of darters of the subgenus *Poecilichthys*. Historically these species have had allopatric distributions maintained by the formidable barrier imposed by Kanawha Falls and the New River Gorge. *Etheostoma osburni* is endemic to the New River drainage of West Virginia and Virginia, above Kanawha Falls, while *E. variatum* is native to the lower Kanawha River, below Kanawha falls, and much of the upper and middle Ohio River drainage. Recently *E. variatum* was introduced into the New River, above Kanawha Falls, and has rapidly expanded its range in the

drainage. A phylogeographic analysis of the subgenus *Poecilichthys*, using DNA sequence data from the mitochondrial cytochrome *b* gene, provided preliminary evidence that *E. osburni* and *E. variatum* are hybridizing in the New River drainage. The goal of this study is to determine the extent of hybridization between these two taxa, using additional molecular markers and increased sampling in the region of contact. This is an important conservation issue, as hybridization may imperil the genetic integrity of *E. osburni*, a species of special concern. Samples have been obtained for 151 individuals of *E. osburni*, *E. variatum* and potential hybrids from 14 localities in the New River drainage, and 104 individuals of *E. variatum* from outside the New River drainage. Sequence data for the complete cytochrome *b* gene and partial nuclear S7 intron 1 have been obtained for all individuals. In addition, each individual was genotyped using 15 tetranucleotide microsatellite DNA loci identified for this study. Details of the spatial patterns of hybridization inferred from the molecular data will be discussed.

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Evidence for production of red snapper *Lutjanus campechanus*, from artificial habitats

Fish production from artificial habitats is a difficult parameter to measure. However by examining several aspects in the life history of red snapper *Lutjanus campechanus* and its association with artificial habitats we may address the benefits of such habitats for this species. In this context, starting in 1989 to the present, we have examined red snapper diets, and the effects of predation, habitat complexity, and epibenthic communities on recruitment. We have also examined movement patterns and population dynamics from fishery independent methods. From these studies we suggest that most red snapper life stages show a high affinity for artificial habitats, showed consistent feeding on reef prey types, were significantly more abundant on reefs with available prey, showed significantly higher numbers with increased reef complexity, showed long term residency (some tracked over 2 years), and showed significantly reduced predator effects with increased shelter on artificial habitats. In addition, from a fishery independent survey of 92 artificial habitats, using fish traps, diver surveys, and otolith aging methods we suggested that populations were higher compared to previous predictive models. Collectively these results suggest that artificial habitats in the northern Gulf of Mexico contribute significantly to the production of red snapper.

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Semilunar reproduction and rapid juvenile growth in the eastern Pacific needlefish *Strongylura scapularis*

Reproduction tied to lunar cycles is common in atherinomorphs, but only anecdotally reported in belonids. This study presents evidence of semilunar

reproduction in the needlefish *Strongylura scapularis* in the Gulf of Nicoya, Costa Rica. Length-frequency distributions of mangrove-collected larvae and small juveniles plotted over a 5.5-week period suggested that cohorts recruited at 2-week intervals. To test whether this periodicity was tied to a semilunar reproductive rhythm, I examined length-frequency distributions of young *S. scapularis* from 124 collections made between 1984-2004, representing all calendar months, and pooled as a function of lunar day. Throughout the year, recently-hatched larvae appeared 1-2 days before new and full moons, and grew rapidly (2.8 to 2.9 mm day⁻¹) to about 90 mm within 1 month. Larvae were uncommon in mangroves until approximately 1 week after hatching, suggesting that *S. scapularis* recruited from outside the study site. Semilunar reproduction in this species may function to disperse offspring to mangrove nursery sites.

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The effect of salinity on the oviposition site selection by *Buergeria japonica*

Choice of appropriate oviposition site is important to increase reproductive success, and many studies have reported oviposition site selection in many animals. *Buergeria japonica* is a ground dwelling rhacophorid frog distributed on most islands of the Ryukyu Archipelago, Japan and on Taiwan. They inhabit and reproduce in the coastal area in which egg mortality seems to be raised by high salinity. For adapting to this habitat, females of this species would have to avoid the high salinity sites for their oviposition site. The purpose of present study is to clear whether females of *B. japonica* have the ability to select the oviposition sites based on salinity difference. I tested the 88 amplexed pairs in laboratory experiments by 9 salinity levels (0‰=control, 1‰, 2‰, 3‰, 4‰, 5‰, 10‰, 20‰, 30‰; seawater is about 33‰), and used the 71 pair for analysis. There are 4 petri dishes for laying eggs in experiment equipment, in which two petri dishes on a diagonal line contained pure water and others contained salt water. Salinity level of 2 dishes was same in each trial. The result of this experiment showed that females of *B. japonica* selected pure water sites more frequently than salt water sites in all salinity levels, except for 1‰ salinity. I conclude that females of *B. japonica* inhabiting the coastal area have an ability to select the oviposition sites to avoid the high salinity.

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Phylogeography and the role of polyphenism in divergence of the Eastern Newt subspecies

Natural selection can drive phenotypic divergence in ecologically important traits. Consequently, reproductive isolation could evolve as a by-product of adaptation to distinct environments, leading to ecological divergence. Polyphenism, a type of plasticity in which a genotype produces discontinuous alternative phenotypes in different environments, has received much attention as a potential mechanism affecting species divergence. The Eastern Newt,

Notophthalmus viridescens, expresses life cycle polyphenism, in which larvae can metamorphose to terrestrial juveniles, aquatic lunged adults, or become paedomorphic adults depending on aquatic conditions. The current designation of four parapatrically distributed *N. viridescens* subspecies is based on differences in morphology and polyphenism expression. Distribution patterns of soil drainage and wetlands suggest that subspecies are distributed in different hydroperiod environments, indicating possible adaptive divergence in polyphenism among subspecies. Previous work demonstrated that differences in polyphenism among subspecies are genetically based, and likely shaped by different pond hydroperiod regimes, suggesting a potential role of life cycle polyphenism in the ecological divergence of *N. viridescens* subspecies. However, patterns of species divergence are dependent on past geological and climatic events as well as adaptation to current environments; thus it is vital to test phylogeographic hypotheses to evaluate the evolution of polyphenism in relation to patterns and modes of species divergence. We designed specific primers for mtDNA cytochrome b sequences of the Eastern Newt and analyzed the sequences of 20 different populations throughout the species range. We confirmed the validity of the primers and found genetic differentiations among subspecies. We are pursuing the further analyses to demonstrate phylogeography of the Eastern Newt subspecies and character evolution of life cycle polyphenism.

***TANAKA, SHO; HAYASHI, TAKEHIRO; SATO, YOSHIO**

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Comparison between elemental microanalysis and traditional staining methods of growth zones in calcified structures of elasmobranchs

We have used mainly their vertebral centra and dorsal spines for ageing elasmobranchs. Recently, neural arches and caudal thorns also have been used for the ageing structures. These ageing structures have growth zones composed of opaque and translucent bands. Several methods for enhancing these bands are described by many scientists, namely immersion and impregnation, sectioning and staining, X-radiography, etc. Elements, Ca and P, of growth zones in the centra of some sharks have been analyzed with X-ray spectrometry or electron microprobe. We compared between elemental microanalysis and traditional staining methods of growth zones in calcified structures of elasmobranchs. Growth zones of vertebral centra, dorsal spines, neural arches and caudal thorns collected from some elasmobranchs were observed alone or by means of sectioning and staining, and X-radiography. These calcified structures were also sectioned, polished and analyzed with electron microprobe (JOEL; JX A-8900R WD/ED Combined Microanalyzer). Fluctuation of Ca and P in the growth zones coincided nearly with the appearance of bands enhanced with the staining methods. The process of making samples for electron microprobe, however, was much time-consuming and specialized. Effective use of elemental microanalysis and staining methods based on data will be discussed.

***TANG, KEVIN L.; MAYDEN, RICHARD L.**

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The Cypriniformes Tree of Life (CToL): A large-scale, international ATOL initiative

The Order Cypriniformes is a clade within the Ostariophysi (Actinopterygii) and is the largest clade of freshwater fishes. The phylogenetic relationships of species in this order have perplexed scientists at least since Artedi erected one of the first scientific classifications of fishes, and the systematic and taxonomic state of affairs within the order can be described as ranging from being fairly well understood to being unquestionably chaotic. Recently, an international team of researchers from many countries have joined efforts to examine fossil and Recent species of Cypriniformes for diversity in morphological, developmental, and molecular traits for resolving the phylogenetic history of this clade of fishes and recovering species diversity within the order. This project has implications that reach far beyond phylogenetic systematics. The central objectives are to: (1) develop an interactive portal for synergistic research and educational activities on Cypriniformes (www.cypriniformes.org); (2) reconstruct relationships of 1000 genera and species using entire mitochondrial sequences, nDNA, and a suite of morphological characters; (3) examine development of 30 species, representing major clades, providing an essential framework for evolutionary, developmental, and systems biology questions in ongoing research programs involving zebrafish, *Danio rerio*, (www.zfin.org); (4) conduct inventories; (5) describe species and produce classifications; (6) examine historical biogeography; (7) test hypotheses of molecular/morphological evolution; (8) provide online database for distributional studies, with FishNet (speciesanalyst.net/fishnet); (9) provide public information on diversity of cypriniform fishes, with FishBase (www.fishbase.org); (10) serve an online key to the major groups and some species, especially commercially important and invasive species. This team of researchers has assembled as an internationally-based Tree of Life (ATOL) initiative of collaboration, formulated within the framework and objectives envisioned by the USA NSF ATOL Program to benefit science and society. Other collaborators are invited and encouraged to participate in this initiative.

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Preliminary results from the Cypriniformes Tree of Life (CToL) Project

The order Cypriniformes constitutes the largest clade of entirely freshwater fishes. The group includes five families with more than 3000 described species in 280 genera. The members of this group are entirely freshwater and found throughout Africa, Asia, Europe, and North America, forming the world's most diverse lineage of freshwater fishes. The diversity of cypriniform fishes includes many economically and scientifically important taxa: the zebrafish, *Danio rerio*, is used as a model organism in evolutionary and developmental studies; a wide variety of cypriniforms are important food fishes in many parts of the world; and they are also ubiquitous in the pet trade. One of the primary goals of the

Cypriniform Tree of Life (CToL) Project is to reconstruct a phylogeny for the entire order. Part of that objective is collecting molecular data in 1000 ingroup taxa. Work on the molecular data collection has begun and sequence data from both mitochondrial and nuclear loci (ND4, ND5, RAG1, and S7) were collected from a broad sampling of species within the order, with outgroups drawn from a number of ostariophysan families. Phylogenetic analyses of these molecular data have provided a preliminary hypothesis of the relationships among the families and subfamilies within the order; these results will be presented.

TAYLOR, CHRISTOPHER M.

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Long-term changes in Oklahoma prairie stream fish assemblages

I used 12 - 19 years of annual data from 22 stream sites in Oklahoma to examine whether fish assemblages exhibited stability or directional change through time, and to relate the magnitude of assemblage change to long-term changes in flow characteristics and watershed scale measures of water use. A modified time series analysis indicated that directional change was occurring for many assemblages, though the strength of this change was highly variable among localities. I used the Indicators of Hydrologic Alteration (IHA; Sustainable Waters Program, The Nature Conservancy) to statistically evaluate the daily record of stream flow over time at each site. Change in flow regime was significantly associated with watershed population density, and secondarily with irrigation activity. Assemblage change was strongly associated with change in flow regime across the sample period. Thus, flow regime was associated with watershed level indicators of water use and accounted for a significant amount of change seen in fish assemblages. These results illustrate how demands on our water resources may ultimately influence riverine fish assemblages by disrupting natural flow regimes.

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An evaluation of surgical closure techniques for retention of telemetry transmitters in American eels

According to recent surveys, American eel (*Anguilla rostrata*) stocks are thought to be in decline. As a result of these declines, there have been calls for an increased understanding of American eel habitat requirements. While telemetry has proven a powerful tool for gaining insights into habitat utilization in other species, low transmitter retention rates have limited its success in American eels. In fact, debate exists over the best method of transmitter placement for American eels. To address this problem, we evaluated transmitter retention times for three commonly used methods of implantation. Individual eels (n=120) were randomly assigned to one of four treatment groups (control, no closure, suture, and surgical adhesive with skin graft) to assess each technique's effect on

transmitter retention. Contrary to published findings, results indicate that suturing of the incision is the most effective implantation method. A better understanding of transmitter implantation techniques will allow for increased utilization of resources and data collection in field projects utilizing telemetry.

***THOMPSON, BRUCE A.; SUTTKUS, ROYAL D.**

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Further revision of the genus *Bembrops*, family Percophidae, suborder Trachinoidei

Thompson & Suttikus (1998) recognized nine *Bembrops* species from the Atlantic Ocean, describing three as new. Thompson & Suttikus (2002) recognized nine Indo-Pacific species, removing several from synonymy and describing one new form. Continued research on the genus has provided new information, including expanded distributions for many species, including *anatirostris*, *grayae*, *macromma*, *magnisquamis*, *quadrisella*, and *raneyi* in the Atlantic, and *morelandi* and *platyrhynchus* in the Pacific. Examination of the holotype (NMW 6458) of *Bembrops caudimacula*, the type of the genus, shows that this name to have been historically applied to the wrong species. The holotype, a male, has a strong anterior dip in the lateral line, a distinct caudal spot, and an elongate genital papilla, characteristic of the form currently known as *B. curvatura*. This change results in *B. curvatura* being reduced to a junior synonym of *caudimacula*. The next available name for the form that has been called *caudimacula* is *B. aethalea* McKay (1971). Two new species are recognized, one from the Queensland coast of northeastern Australia (looking superficially like *B. filiferus*, but with fewer dorsal and pectoral rays, fewer lateral-line scales, and longer spinous dorsal filament) and a second species from the Red Sea and Gulf of Aden in northeast Africa, called 'western' *caudimacula* in Thompson & Suttikus 2002, but distinguished by a darker spinous dorsal fin, fewer lateral-line scales, and a more distinct cross-hatch body pattern than *B. aethalea*. *Bembrops cadenati* Das & Nelson (1996) is the correct name for the west African Atlantic form that has been called *heterurus*, leaving this latter name to be restricted to the western Atlantic species off southern Brazil.

***THOMSON, ALFRED W.; PAGE, LAWRENCE M.**

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Genera of Sisoridae and Erethistidae

Following a phylogenetic analysis of species traditionally assigned to the Asian catfish families Sisoridae, Akysidae, and Amblycipitidae, de Pinna (1996) recognized Erethistidae for six genera previously assigned to Sisoridae (*Conta*, *Erethistes*, *Erethistoides*, *Hara*, *Laguvia*, and *Pseudolaguvia*). Sisoridae is distributed throughout much of southern Asia from the Tigris-Euphrates basin in Iraq to Borneo. Erethistidae is found mainly in the Ganges and Brahmaputra drainages in India, Nepal, and Bangladesh, and the Irrawaddy and Salween drainages in Myanmar. De Pinna diagnosed suprageneric clades including Erethistidae and

Sisoridae, but he did not diagnose genera. Our objective is to examine all publications providing diagnostic information on sisorid and erethistid genera and, in conjunction with the examination of specimens, provide morphological diagnoses for all described valid genera in Sisoridae and Erethistidae. A phylogenetic analysis of relationships among species in the two families would be preferable prior to diagnosing genera; however, we have insufficient access to specimens to perform such an analysis. Meanwhile, even though some of the genera are poorly diagnosed and appear to lack traits to distinguish them from other genera, descriptions of new species in Sisoridae and Erethistidae continue to appear (e.g., Ng & Kottelat, 2000; Britz & Ferraris, 2003). We believe that a thorough analysis of the literature and a summary of valid diagnostic traits will significantly facilitate taxonomic work in these families. Sixteen sisorid genera (with about 120 species) and five erethistid genera (with about 19 species) are considered valid as a result of this study.

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Seasonal and spatial patterns of Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*) captures in South Carolina coastal waters

Seasonal population trends of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) were analyzed from 4684 specimens collected by the South Carolina Department of Natural Resources from coastal waters surrounding the greater Charleston area between March 1998 through December 2002. Specimens were collected using longlines, gillnets, and hook and line method. Preliminary analyses of the data show strong seasonal fidelity of adults and pups to certain locations. Pups were most abundant within estuaries during the spring and summer months, and adults were most commonly captured in nearshore oceanic waters during the spring, summer, and fall. Males were more abundant than female adult sharks, indicating the possible sexual segregation of adult Atlantic sharpnose sharks in certain coastal environments. Data on fishing gear selectivity and geographical GSI spatial analyses of female and male adult and pup spatial distributions will be further examined.

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Fishes of the Atchafalaya River Delta (Louisiana, USA) with comments on the influence of geomorphological and anthropological changes

The Atchafalaya River is the only area along the Louisiana coast that is not losing wetland acreage. Islands are forming due to the natural input of sediments

associated with approximately one-third of the Mississippi River flow that is permitted to enter the Atchafalaya River system. This results in the Atchafalaya Bay estuary being strongly influenced by the presence of large amounts of fresh water. The bay has been altered from a completely open system to the present situation of large, shallow subareal mudflats and numerous deltaic islands. These shallow habitats are constantly changing with the depositional/erosional geomorphological deltaic cycle, resulting in habitats becoming common or rare depending on the phase of the cycle. At present, the aquatic ecosystem of the delta is dominated by very turbid riverine fresh water. Fish sampling from the early 1980's to the present produced 92 fish species: 40 freshwater (FW), 17 estuarine (ES), 28 estuarine/marine (ESM), 5 marine (MA), 1 catadromous (CA), and 1 anadromous (AN). Comparisons of 1981-82 fish species with ongoing studies show some variation over time, but nothing that suggests major ecosystem changes: 26 vs 36 FW, 15 vs 17 ES, 25 vs 20 ESM, 4 vs 2 MA, 1 vs 1 CA, and 0 vs 1 AN. Our ongoing studies are directed at fish usage of artificial habitats constructed over the past 8-10 years, and results point to the man-made habitats supporting similar fish assemblages compared to more natural habitat formed during the recent depositional delta cycle in the 1980's. Both the natural and man-made habitats have been shown to be valuable nursery areas for a wide range of fish species. Our current research is directed at whether man-made habitats can be "retrofitted" to enhance their quality for fish habitat.

***TILLET, BREE J; TIBBETTS, IAN R.**

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Prey discrimination and foraging behaviours of the Bluespotted Stingray, *Dasyatis kuhlii* (Muller and Henle, 1841) in Moreton Bay, Australia

The Bluespotted Stingray, *Dasyatis kuhlii* is a benthic elasmobranch that is common in Moreton Bay. Prey selection, foraging efficiency and foraging behaviours of 10 rays were observed in controlled laboratory experiments in which a selection of prey species and sizes were offered at depths of either 1 cm or 5 cm in sand. Additional experiments were also conducted to test their ability to discriminate artificial electric fields of different strength and depth, and to determine the relative dominance of olfactory, electrical or mechanical cues in stingray foraging. Bluespotted stingrays discriminate species and size of buried prey ($p < 0.01$, $p < 0.03$ respectively), though depth did not influence prey selection ($p > 0.05$, $p > 0.05$ respectively). Rays often excavated prey species that they did not subsequently consume suggesting that they are not accurately able to discriminate among buried prey. All sizes of their preferred prey were consumed once acquired, although rays were unable to determine prior to excavation if buried prey are too large to consume. Among sensory modalities tested, there was a clear preference for electrical stimuli ($p < 0.02$), although olfaction was also important in prey detection. Rays did not discriminate between electric fields of different strength and depth ($p < 0.05$) indicating that blue spotted maskrays are unable to resolve the interaction between prey depth and prey size. The implications of these findings for the foraging biology of stingrays are considered.

***TODD, BRIAN D.; ROTHERMEL, BETSIE B.; GIBBONS, WHIT**

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Forest clearing reduces growth and survival of recently metamorphosed southern toads (*Bufo terrestris*)

Forest alteration threatens the persistence of many amphibian populations and most studies to date have relied on comparative monitoring techniques and abundance data to determine the impact of forest alteration on amphibians. Many of these studies suggest that local populations decline following significant alteration such as forest clearing. However, the mechanisms responsible for these declines often remain unexplored. Population-level mechanisms that may contribute to amphibian declines following forest harvest include emigration, barriers to successful reproduction, reduced juvenile recruitment, reduced postmetamorphic growth, and reduced postmetamorphic survival. In this study we focused on two of these mechanisms, survival and growth rate, in recently metamorphosed southern toads (*Bufo terrestris*) using terrestrial field enclosures in two habitat types - unharvested loblolly/longleaf pineforests and recent clear-cuts. Because southern toads are cryptic animals, it is often impossible to completely census all living animals in a sampling period. Therefore, we used a robust mark-recapture design to census the toads over two months and we used program MARK to estimate the number of surviving toads at each sampling period. After two months, survival was approximately 67% lower in clear-cut enclosures than in forested enclosures. Surviving toads also grew less in clear-cuts than in unharvested forests. Our results unambiguously identify reduced survivorship and lower growth rates as possible mechanisms for amphibian population declines following forest clearing. To more fully understand population-level effects of forest clearing, we are currently initiating similar mechanistic studies on dispersal and migration. **SSAR SEIBERT CONSERVATION**

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Observations on subterranean aquatic habitat use and early nesting by the Southern Two-lined Salamander (*Eurycea cirrigera*)

On January 26, 2005, while surveying the amphibian community of a privately owned cave (near the base of Short Mountain in Cannon County, Tennessee) we found six nests of *Eurycea cirrigera*. Nests were located past the twilight zone, but within the first 300ft of cave passage, and were attached to the underside of submerged rocks in the cave stream. Adult females were found attending two of these nests. We returned on Feb 09 and located four of the original and one new nest. Females were again found attending two of the nests. We returned again on Feb 26 and located one of the original and two more new nests, one with an attending female, bringing the total to nine nests. On all three dates, nests were photographed and analyzed digitally to determine diameter of eggs and length of embryos. Clutch size ranged from 32-71 eggs ($X = 55.11 \pm 8.36$) and ranged in developmental stages from Harrison stage 10 to Harrison stage 42. Eggs in

earlier stages were white and ranged from 2.5-3.5mm in diameter. Embryos in later developmental stages still lacked pigmentation of the integument, including those where pigmentation of the iris was visible. The advanced stages of some of the clutches found on 26 January and the rate of development determined in the clutches observed multiple times indicate that some clutches were oviposited during December. This observation documents the first use of subterranean aquatic habitats for oviposition by *E. cirrigera* and one of the earliest occurrences of oviposition in Tennessee.

***TOLSON, PETER J.; GARCIA, MIGUEL A.; ELLSWORTH, CANDEE L.**

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Habitat use of the Mona Boa, *Epicrates m. monensis*, on Isla Mona, WI

Observations of the foraging activity of the Mona boa, *Epicrates m. monensis*, were made in subtropical dry forest on Isla Mona, WI. One hundred ninety seven observations of 103 individuals were made from 1 August 95 through 10 January 05. Habitat use was quantified in terms of foraging height, perch diameter, tree or shrub species selected, and nearest neighbor distances to neighboring vegetation. Capture sites were characterized by densities and frequencies of tree and shrub species within a 10 x 10 m plot with the capture site used as the plot center. Using ANOVA, different age classes of boas showed no significant differences in foraging height, but large adults showed a bimodal distribution of foraging height, foraging either on the limestone substrate or high in the open canopy. Neonates and subadults showed no significant differences in perch diameter, but snakes 600-699 mm SVL and snakes > 700 mm SVL showed significant differences in perch diameter from the two smallest size classes as well as from each other. Smaller snakes usually foraged in small trees or shrubs, showing a slight preference for smaller trees such as *Ficus citrifolia*, *Antirhea acutata*, and *Caesalpinea monensis*. Large adult snakes were found most frequently on the ground foraging in or around *Tillandsia utriculata* or high in the canopy in *Clusia rosea*. Vegetation plots in the study sites had mean tree (> 10 cm DBH) densities of 0.03 trees/m² and small tree and shrub densities of 0.44/m².

***TONIONE, MARIA; HOSKIN, CONRAD; MORITZ, CRAIG**

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Phylogeography of an Australian wet tropics rainforest endemic, the microhylid frog *Cophixalus ornatus*

Comparative phylogeography of the rainforest fauna from the Australian Wet Tropics has revealed marked effects of late Quaternary rainforest contractions. Analysis of the microhylid frogs of the genus *Cophixalus*, reveal much of the biogeographical history of the Wet Tropics, as they are generally montane and fragmented into highly localized, allopatric distributions. We integrate data from the genetics, morphology and breeding calls of *Cophixalus ornatus*, in order to

identify the patterns and processes responsible for observed diversification. Phylogenetic analysis of both mitochondrial and nuclear data suggest five genetically distinct localized lineages, several of which match predicted refugia based on paleoecological modeling. Preliminary analysis of a nuclear intron with diagnostic sites among lineages shows limited hybridization between clades. Significant differences in morphology and calls between lowland and upland clades correlate to ecology (larger body size and lower call frequencies at higher altitudes). These results all support the role of refugial isolation in phenotypic and genotypic divergence. The mechanisms of diversification in the Wet Tropics fauna may often relate to extended periods of allopatry which can occur at different spatial scales. It is notable that the relative scale of the biogeography and speciation in microhylids is more analogous to scenarios proposed for invertebrates (e.g., snails, beetles) as opposed to other co-distributed herpetofauna (e.g., stream frogs, dragons, skinks, geckos).

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Reproduction in parasitized female threespine stickleback: Is the host getting the best or worst of a bad situation?

Parasitic infections often entail a reduction in host energy stores and/or reproductive rate. Such changes in host life history may reflect: 1) a parasite strategy: the parasite manipulates energy flow within the host, such that the host is induced to reduce its investment of available energy stores in reproduction; 2) no strategy: there is no change in the proportional allocation of energy stores to reproduction, so that reproductive rate decreases as energy stores decrease via nutrient theft; 3) a host strategy: the host increases its allocation of energy stores to reproduction to maximize fitness, making the best of a bad situation in spite of infection and loss of condition. Females in Alaskan lake populations of threespine sticklebacks (*Gasterosteus aculeatus*) continue to reproduce when infected by the cestode *Schistocephalus solidus* despite large body burdens. We analyzed parasite infection rate and intensity, host somatic energy reserves, and reproductive allocation, of females collected from an Alaska lake during a single reproductive season. We found that infected females exhibited lower reproductive rates and energy stores than uninfected females. The relationship between reproduction and energy storage did not differ between infected and uninfected females. The host is not getting the best or worst of a bad situation; it does not change its reproductive allocation of stored energy in response to parasitism. Thus, the hypothesis that nutrient theft is involved in the parasitic influences on host reproduction is supported by our results.

TORKI, FARHANG

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Annual cycle of sexual system of male *Ophisops elegans* considering hibernation, morphology, and histological

Study of this subspecies of *O. e. elegans* has been done , which has a rich dispersion in western plateau of Iran . Geoclimatical and ecological study of western of Iran in middle zagros in which sauria , have full hibernation . Two years survey of the species hibernation shows that from late Oct to late Feb this hibernation lasts . Climatical factor during hibernation survey . Were studied after determination of this subspecies hibernation , in the following year from Mar to Oct , sampling of species and sexual system has been done . Result of study of morphometrical and histological shows that decrease of male sexual system activity from Mar to Oct . This decrease from Mar to Jun is obvious while from Jul to Oct minus gradient of male sexual system is obvious slightly . According to observation brown adiposite storage is the only factor that leads to growth of male sexual system during hibernation. Adiposite storage from Jul has been started and it can observed after hibernation until Apr.

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Base factor on home ranges

Home ranges (HR) was defined by Burt as the area transverd during the the natural activity of food gathering, mating and caring for young and this definition is still widely used. But this definition is not factor on HR. I found Base Factor on HR, when the smallest changing on BF changing widely in other factors on HR, termal condation, mates, body size, and so on are not BF. Three biome in Iran Plateau was studied ecological, climatical and geographycal in varying selected station. Then, for the testing of survey on the station and condation, used the Correlation Regresion and Cluster Analysis, in the resultes was obtained decrease of station and varity of sauria in this plateau. Then survey of changing in food on the sauria and Population condens*eggs numeral and relationship these factors with the surce of nutrients along with condens and variety of florestics was caused that, HR of sauria divide in two groups. In accourding to the results of statica analysis diversity in the dispersal is limited by charactris of each ecosystem. Firest group widly area (diperesd on variaty biome) and second group dispersed on only biome. The most important factor in the area of HR is Variety*Condens of florestica in the area. Because the smallest change in this factor change HR of sauria widely. For example HR for genus of *Tropicolotes* is limited in forester and HR area for genus of *Laudakia* is limited in nonforester mountains. This two genus have stenovalance HR and the other hand genus *Ophisops* and *Mabuya* is dispersed in three bome and have a euryvalance HR. Although these species are not herbivor, but their dispers was affected with BF.

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Death feigning and autotomy behavior of the Mexican Blind Lizard (*Anelytropsis papillosus*), from Guadalcázar, San Luis Potosí, México

At the time, very little is known about biology of *Anelytropsis papillosus*. On 21 November 1996, was collected an adult male *A. papillosus* under a yucca's trunk in xerophil scrub at municipality of Guadalcázar, San Luis Potosí, México. When the specimen was collected, it responded aggressively biting the collector's fingers continuously and intensely, for three or four minutes, after that the specimen remains motionless in collector's hand two or three minutes, in a behavior of faking dead, until if it feels safe and become to move slowly. The same behavior was presented by another adult male *A. papillosus* which was collected on 19 April 1999, under a yucca's stem in xerophil scrub in the same municipality. However, the latter specimen after bite the collector's fingers, it remains motionless for 10 or 15 seconds, and suddenly make a quick lash and suffered an autotomy of almost the half tail and tried to escape moving toward another direction.

***TOUCHON, JUSTIN C.; WARKENTIN, KAREN M.**

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Interacting risks: rainfall reliability and egg predation in the Neotropical treefrog, *Hyla ebraccata*

The treefrog *Hyla ebraccata* lives in humid tropical forests from southern Mexico through the Chocó of Columbia. It lays eggs on vegetation over water, into which tadpoles hatch after 3-4 days. *H. ebraccata* breeds throughout the rainy season at a variety of sites, from rainforest ponds to open marshes. Females put little water into the egg jelly, thus clutches require rain for normal development. We used field observations and experiments to examine the direct effects of rainfall on clutches, and potential interactions with predation risk. We monitored 250 egg clutches at two ponds near Gamboa, Panama in 2003 and 2004. In clutches that received no rainfall, 95% of embryos died from either desiccation or predation. The direct threat of desiccation is partially ameliorated by shade coverage. Eggs laid in less than 30% shade died from desiccation in 55 hours without rain, whereas those in 80% or more shade survived an extra 23 hours. To test interactions between weather and egg predation, we exposed clutches to simulated heavy rainfall and dry periods. The clutches thus hydrated or desiccated were presented to predators in simultaneous choice tests. Egg predation by ants (*Azteca sp.*) and wasps (*Polybia rejecta* and *Agelaia centralis*) was over seven-fold higher on desiccated clutches. In a similar experiment, we exposed clutches to simulated heavy rainfall or lack thereof and measured

hatching timing. Eggs that were rained on hatched 20% earlier than desiccated eggs, further reducing their exposure to egg predators. Current climate predictions for the neotropics indicate that precipitation will increase, but be more sporadic. In Gamboa, between 1970-2000 the number of dry days per rainy season has doubled, despite no change in average annual rainfall. Both increasingly sporadic rainfall and reduced shading due to forest clearing could substantially reduce *H. ebraccata* egg survival.

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Variation in larval predation risk across breeding sites of two hylid frogs

Differences in predator faunas among ponds may have important consequences for larval anuran communities. In this study we examine interactions between the tadpoles of two pond breeding treefrogs, *Hyla ebraccata* (pantless treefrog) and *Agalychnis callidryas* (red-eyed treefrog), and their predators through a combination of field surveys characterizing predator faunas and experiments to quantify predator efficacy. We characterized the predator faunas of six ponds near Gamboa, Panama, where both frog species breed. We then conducted short-term predation trials with hatchlings of both frogs to estimate the predation rates for 12 putative predator taxa found in these ponds. The relative abundance and the predation rates of predators were combined to provide an index of relative predation risk to compare among sites. There was considerable variation in the index of risk, a pattern driven by large variation in efficacy among predator taxa and the patchy distribution of the most effective predators, giant water bugs, dragonfly larvae, and fish. We selected two common, effective predators, giant water bugs (*Belostoma* sp.) and a libellulid dragonfly larvae, to quantify size-specific predation rates on the tadpoles of both species. Water bugs and dragonfly larvae were effective at preying on different size classes of tadpoles. Giant water bugs were effective predators of intermediate and large tadpoles but poor predators of very small tadpoles, while libellulid dragonflies were most effective preying on small tadpoles and were unable to prey upon the largest size classes. These results suggest that the importance of larval predation for juvenile recruitment varies among ponds and that differences in the ontogenetic size range of the larvae among frog species and the size-specific predation rates among predators may result in differences in recruitment across ponds for each frog species.

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Comparative sperm morphometry in three South American snake taxa: Considerations on sperm competition theories

The functional and evolutive significance of sperm length variation considering postcopulatory sexual selection remains poorly understood as the production of long sperm can be costly and the advantage of sperm size remains enigmatic. An increment in sperm size may either increase its longevity if size signifies energy reserve, or trade it off with swimming speed by increasing tail length plus its associated mitochondria in the midpiece. Sperm competition may also select for bigger sperm because they are able to displace smaller competing sperm or serve as an indicator of male genetic quality. Even cryptic female choice may also contribute to selection of a more competitive sperm phenotype. Snakes show reproductive characteristics like promiscuous mating systems, long and short term sperm storage and unique structural spermatid features, being excellent study subjects to test sperm competition hypotheses. The objective of this work was to detect variations in sperm morphometry across snake taxa and to relate it to differential sperm competition pressures. The length of the head, acrosome, midpiece and principal piece of spermatozoa of three snake taxa: Boinae, Crotalinae and Xenodontinae, was measured using phase contrast and fluorescence light microscopy. Data were controlled for normality and a parametric analysis of variance (ANOVA) was performed for each variable. Pairwise differences among means were tested a posteriori. Although head length did not varied significantly among taxa, the acrosome, principal piece and particularly midpiece length showed significant variation. Results are discussed in the light of sperm competition theories that suggest it would be possible to expect variations in sperm length according to sperm competition risk derived from differences in species attributes like life histories, reproductive cycles and mating systems.

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Reproduction of Port Jackson sharks off south-eastern Australia

The Port Jackson shark (*Heterodontus portusjacksoni*) is a common demersal shark off southern Australian waters. Tagging studies suggest the existence of different populations along the Australian coasts. General information about its reproduction has also been reported, but possible differences in the reproductive parameters of sharks from different areas have never been studied. The aim of the present investigation was to determine the reproductive parameters of the populations off south-eastern Australia. Sex, total length (TL), clasper length and maturity condition were recorded from sharks collected from commercial catches; and used to estimate length at maturity. Ovarian fecundity was recorded and compared to the number of eggs laid by sharks held in captivity. The

reproductive cycle was determined based on the proportion of females with completely developed follicles and the size of the follicles through time. Biological data from the 712 Port Jackson dissected sharks indicated that males mature at around 800 mm TL and females between 850 and 1000 mm TL on the east coast of Victoria. This species has an annual reproductive cycle. Ovulation time is strongly correlated with water temperature, starting at the beginning of spring. Females have a long egg laying period (Late August to March) and lay up to 18 eggs per reproductive season. Egg hatching takes place in winter. Differences in the size at maturity were found between males from the east and the west coast of Victoria, suggesting the presence of at least two populations.

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Diversification of hyloid frogs: A nuclear perspective

Hyloidea comprises an array of diverse lineages representing the majority of species within the neobatrachian ("advanced") frogs. Historical studies have had difficulty defining the relationships among many of the hyloid sublineages. The mitochondrial 12S/16S work of Darst and Cannatella (2003), for instance, clarified many relationships *within* Hyloidea while also finding several near-zero length branches defining relationships *among* the sublineages. This could be due to insufficient resolving power of the mitochondrial data in the deeper regions of the tree (i.e., an artifact of the analysis) or it could be due to a markedly rapid diversification from the ancestral hyloid lineages. We test these alternatives by constructing a densely sampled phylogeny using the nuclear gene RAG-1. Truly rapid diversification will be supported if nuclear data also recover extremely short branches among the major sublineages. We also address topological congruence between mitochondrial data and our own and resolve relationships of other taxa not sampled in mitochondrial trees, such as *Insuetophrynus* and *Rhinoderma*.

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Molecular phylogenetics of Malagasy leaf chameleons (Genus *Brookesia*)

Malagasy leaf chameleons (*Brookesia*) comprise more than 20 species of small, often brownish, largely terrestrial chameleons, typically found amid the debris of the forest floor. This group, which contains some of the smallest known vertebrates, is distributed widely in the eastern and northern rainforests of Madagascar, with a few species inhabiting the drier regions of the west. A lack of easily identifiable, fixed morphological differences between species (exacerbated

by their small size) has contributed to the lack of a formal phylogenetic classification of these animals. Nonetheless, informal attempts at clustering them into natural groups have been made based on morphological (including size) and behavioral characters. We tested these predictions with a molecular phylogenetic study utilizing both nuclear and mitochondrial genes. We use our results to examine the evolution of antipredator behaviors and extreme miniaturization in this group, as well as Malagasy biogeographical patterns.

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Population structure of thresher sharks (*Alopias* spp.) based upon mitochondrial DNA control region sequence data

The family Alopiidae is comprised of three species: the pelagic (*Alopias pelagicus*), bigeye (*A. superciliosus*), and common (*A. vulpinus*) thresher sharks. *Alopias pelagicus* is found only in the Pacific and Indian oceans, while the other two species are distributed worldwide. Despite growing conservation concerns, genetic relatedness among thresher shark populations is poorly known. We examined the population genetic structure of each species using DNA sequences from the mitochondrial control region. Samples of *A. pelagicus*, *A. superciliosus*, and *A. vulpinus* were collected from the East (n = 0, 15, 14) and West (n = 0, 6, 39) coasts of the United States, Gulf of California (n = 23, 1, 0), Clipperton Atoll (n = 3, 0, 0), Ecuador (n = 22, 14, 0), Hawaii (n = 0, 13, 0), Taiwan (n = 5, 11, 5), Indonesia (n = 25, 0, 0), New Caledonia (n = 1, 0, 0), New Zealand (n = 0, 0, 5), South Africa (n = 0, 1, 5), and France (n = 0, 1, 5). Despite their high dispersal potential, our data indicate limited gene flow among thresher shark populations, but geographic patterns of genetic variation differ among species. Gene flow in *A. pelagicus* is limited across the Pacific Ocean, but is extensive among locations in both the eastern and western Pacific. In *A. superciliosus*, genetic heterogeneity was detected among Pacific and Atlantic populations, but not among populations spanning the entire Pacific Ocean. Results for *A. vulpinus* indicate genetic heterogeneity among all sampled populations, both within and between the Atlantic and Pacific oceans. Taken together, our data indicate that intra-specific biological and ecological differences among thresher sharks are sufficient to cause variable patterns of inter-specific genetic population structure. This study also highlights the need for international cooperation in management of thresher shark populations. **AES GRUBER**

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A comparison of different methods and structures for age determination of skates in Australian waters

Skates are a common by-catch/by-product of both State and Commonwealth

demersal fisheries that operate around Tasmania, Australia. Two large-bodied skates, *D. whitleyi* and *D. gudgeri* are harvested for their flesh on the domestic market. In the south-east trawl and non trawl fishery about 55% of *D. whitleyi* and 22% of *D. gudgeri* are retained. The total catch of skates is essentially unregulated with very little recorded on a species-specific basis. Little is known of the life history of any of the skates found in southeastern Australia. The vertebrae and caudal thorns of seven skate species were collected from commercial fishers from around Tasmania and examined for ageing readability. Various ageing techniques were trialed on these different structures. *Dipturus gudgeri* (n=300) and *D. whitleyi* (n=73) showed the most promising band formations in both structures using two different methods: whole and sectioned vertebrae and whole and sectioned caudal thorns. A strong correlation between caudal thorn length, width, height and the animals total length indicated that caudal thorns continue to grow throughout the animals life. This was also apparent with the vertebral centra. The two largest vertebrae and two least worn caudal thorns from each animal were prepared for ageing. Centra were sectioned longitudinally and the caudal thorn was sectioned both transversally and diagonally to assess the apex of the thorn. Bands present on the surface of the thorn and those in thorn sections were compared with vertebral whole and sectioned counts. Variable differences between the number of bands on/in the caudal thorn and the vertebrae were found. Growth increments derived from whole and sectioned vertebrae were insignificant. Difficulties were found in reading the deeply coned vertebrae of *D. gudgeri* and counting bands near the edge of whole vertebrae for both species. Consistency was found in surface and internal band counts of caudal thorns.

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Reproductive Endocrinology and Estimation of Demographic Parameters of Puget Sound Spiny Dogfish

A one year study was undertaken to investigate reproductive parameters and endocrinology of spiny dogfish (*Squalus acanthias*) in Puget Sound, WA to aid management of the commercial fishery. Size at maturity, fecundity and reproductive timing were estimated from 416 females and 185 males sampled from a commercial trawl catch. Size at 50% maturity was estimated at 89.9cm for females and 66.6cm for males, fecundity was an average of 6.85. The pupping season was determined by the stage of embryonic development and found to peak in September and October. Serum samples were collected from 203 females and 144 males. Samples were assayed for concentrations of estradiol and progesterone (females), and testosterone (males). The results presented here show that distinct reproductive stages can be identified by the hormone concentrations alone with greatest accuracy at the most critical management stages. Sampling blood from live dogfish is less invasive and costly (both

economically and timely) than sacrificing and dissecting dogfish to determine reproductive state, making monitoring the reproductive cycling of a population less of a process for fishery managers. **AES GRUBER**

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Is the evolution of pairing behavior in chaetodontid butterflyfishes driven by acoustic communication?

Butterflyfishes of the genus *Chaetodon* (family Chaetodontidae, 10 genera, 126 spp) show a strong propensity for pairing behavior, and unique swim bladder and laterophysic morphologies that may function to enhance hearing and social communication. We tested the hypothesis that pairing behavior facilitates acoustic communication. Bioacoustic behavior experiments with fish pairs show that multiple classes of low intensity acoustic vocalizations are produced during social interactions in three different subgenera and species: *C. Exornator multicoloratus*, *C. Rabdophorus auriga* and *C. Citharoedus ornatissimus*, but also in an outgroup species *Forcipiger flavissimus*. Thus, the production of weak acoustic sounds during social interactions is widespread but not restricted to *Chaetodon*, and may have evolved broadly within the family. In *Chaetodon multicoloratus*, three sounds are associated with specific kinematic action patterns. The click (mean duration = 4.3 ms, peak frequency = 10,384 KHz) is produced during tail slap behaviors, short pulses (5.1 ms, 238 Hz) during pelvic fin movements, and long pulses (199 ms, 20 Hz) during body oscillations. Mean sound pressure levels of these vocalizations range from 119-128 dB re: 1 Pa at a distance of <1 body length from the source. Hearing thresholds in the 100-2000 Hz band were determined for *C. multicoloratus* by auditory brainstem response experiments. Fish showed best sensitivity between 100-600 Hz at an average threshold of 116 dB re: 1 Pa. These results show that auditory thresholds in *C. multicoloratus* are near the source intensity of their social vocalizations, thus acoustic communication may be constrained to short inter-individual distances. Field observations on inter-pair separation in four *Chaetodon* subgenera confirm the prediction that acoustic mediated communication should be limited to 1-2 body lengths. These findings are consistent with the hypothesis that close and frequent pairing behavior has evolved to enhance vocal communication in butterflyfishes. *Supported by NSF IBN0137883*

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Demographic biology of the sparsely-spotted stingaree *Urolophus paucimaculatus* from south eastern Australia

Studies of the reproduction of *Urolophus paucimaculatus* in south eastern Australia were undertaken at several sites including Port Phillip Bay, Lakes

Entrance and Western Bass Strait during August 2002-March 2005. Ovarian follicle development and seasonal embryonic growth indicate a 1-year gestation period in synchrony with a 1-year ovarian cycle. Litter size increases with maternal length with a maximum of six offspring per pregnancy. *U. paucimaculatus* exhibit aplacental viviparity with trophonemata, the embryos utilize the yolk from the yolk sac early during gestation and histotroph during the later phase of embryonic development. Parturition occurs during September-December. Maximum embryo size is 161 mm TL and 42 g mass. There is no obvious mating season or seasonal trend in hepatic somatic index or gonadosomatic index. For the female population, 50% are mature at 270 mm TL, and for the male population 50% are mature at 278 mm TL. The maternal length where 50% of the population is contributing to the next year recruitment is 358 mm TL.

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Variation in stream fish sexual dimorphism across a rural-urban gradient

Sexual dimorphism is a common phenomenon involving development of different morphological characteristics between males and females of a species. Among many freshwater fishes, sexual dimorphism often involves differences in fin size. Specifically, males have larger paired ventral fins and females have longer anal fins. These differences were examined in blacknose dace (*Rhinichthys atratulus*) from eight streams that extend across an urbanization gradient. Watershed urbanization results in changes in the physical habitat of streams and input of pollutants such as endocrine-disrupting chemicals. Because development of sexual dimorphic characteristic are under endocrine control and may also be influenced by the physical habitat of streams, we expected to find differences in the degree of sexual dimorphism along the gradient. Results to date indicate significant variation in the degree of sexual dimorphism in fin lengths among the eight populations. Furthermore, variation in degree of sexual dimorphism among populations was at least partially related to degree of watershed urbanization. Populations from the two most urbanized watersheds showed unique sexual dimorphisms and another urban population lacked sexual dimorphisms in anal fin length.

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Myological characteristics suggest the presence of a short neck in snakes

In snakes, the complete loss of the pectoral girdle, coupled with the morphologically homogeneous precloacal vertebrae, obscures the distinction between cervical and trunk regions. Several criteria have been used to recognize the snake "neck," resulting in contradictory inferences. A study based on the number of vertebrae bearing hypapophyses suggests a long neck in snakes,

whereas studies of the coelom and of *Hox* gene expression patterns suggest that the snake neck is extremely short or not present at all. We used comparative anatomy of two muscles to further investigate this issue. The first muscle, *m. spinalis capitis*, connects the skull with neural spines of the cervical and anterior dorsal vertebrae in tetrapodal squamates, for example arising most posteriorly from the eleventh and eighth vertebrae in *Iguana* and *Varanus*, respectively. In snakes that we examined, the most posterior origin of this muscle varies, ranging from the tenth vertebra (e.g., *Loxocemus*) to the *m. semispinalis* tendon inserting on the axis (typhlopids). The second muscle, *m. cervicoquadratus*, has previously been regarded as a part of *m. obliquus externus* or *m. constrictor colli*. However, it is here proposed as a homologue of *m. episterno-cleido-mastoideus* based on similarity in origin and insertion. In other squamates, this muscle connects the pectoral girdle with the skull; the posterior extent of *m. cervicoquadratus* may thus shed light on the length of the neck. *M. cervicoquadratus* arises from the surface of *m. rectus abdominis* at the levels of the seventh (e.g., *Cylindrophis*) to second (typhlopids) vertebrae. These observations indicate that the neck of the examined snakes is less than ten vertebrae in length, which is fairly comparable to that in other squamates. Conflicting results from studies of different anatomical and developmental systems suggest that no single criterion may be sufficient to delimit the "neck" in snakes.

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Translocation as a conservation tool: Site fidelity and activity area size of repatriated gopher tortoises (*Gopherus polyphemus*)

Efforts to evaluate the efficacy of translocation as a conservation tool have mostly been inadequate, particularly for reptiles and amphibians, leading many biologists to discount translocation as a viable management option. Nonetheless, with two-thirds of the tortoise and freshwater turtle species in the world at risk, translocation may be one of the few remaining options for re-establishing extirpated populations and reconnecting fragmented ones. We translocated 106 gopher tortoises (*Gopherus polyphemus*) of all size and age classes to a protected area within the historical range but with no resident tortoises, and tested the effects of penning on site fidelity and activity area size. We assigned 38 adults and subadults to one of three penning treatments (9-mo., 12-mo., and no penning) and radio-tracked them for two years. Penning significantly increased site fidelity and resulted in smaller activity areas. Our data suggest that translocation coupled with penning will improve the likelihood of establishing self-sustaining tortoise populations. **STORER HERPETOLOGY**

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Activity and movement patterns of eastern (*Heterodon platirhinos*) and southern (*H. simus*) hognose snakes in South Carolina

The southern hognose snake (*Heterodon simus*) is a fossorial snake restricted to the Coastal Plain of the southeastern U.S. The species is infrequently encountered, is perceived as rare, is considered extirpated from large portions of its former range, and has apparently disappeared from relatively pristine areas with large tracts of appropriate habitat. In contrast, its congener, the eastern hognose snake (*H. platirhinos*), is still relatively common. The range of the eastern hognose snake includes the southeastern U.S., where it occurs sympatrically with the southern hognose snake. The purpose of this study was to compare activity and movement patterns in both species in an attempt to identify potential reasons for the decline of the southern hognose snake and to develop management recommendations for both species. A long-term (>50 yrs) database of observation and locality records reported from the Savannah River Site (SRS), South Carolina was used to determine seasonal and annual activity patterns of each species. In addition, 5 eastern and 5 southern hognose snakes were radio-tracked for 1-14 months during 1998-2002. Tracking data were used to calculate home ranges (MCP, kernel), determine proportion of time spent on surface vs. below ground, identify types of refugia, and to compare activity patterns based on telemetry data to those determined from the observational database.

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Evaluating local vs regional management: A study of tautog (*Tautoga onitis*) in Virginia

The tautog stock complex from Virginia to Massachusetts is assessed as one stock using a virtual population analysis. Estimated mortality of the stock has exceeded the target and resulted in mandated reductions in fishing effort. However, two states (Virginia and Rhode Island) have argued that mortality rates in their jurisdictions are below the target value and thus the states should be exempted from the reductions. In Virginia, non-equilibrium, cross-sectional catch-curve analyses consistently show mortality rates are less than the target and that mortality rates have declined over time. Tagging data show that Virginia tautog do not move to other states thus providing a mechanism for localized mortality rates. However, the catch-curve results are also consistent with an alternative explanation that recruitment has declined in Virginia. It might be argued that because of the possibility that recruitment has declined it would be conservative to impose a reduction on Virginia fishing effort. However if mortality rates are lower than the stock-wide average then imposing a reduction in Virginia causes a loss of legitimate yield (yield consistent with the management goals) while failing to alleviate the overfishing elsewhere. Simple

models used for local assessment can thus have an advantage over a sophisticated model applied to an entire stock complex.

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Developmental morphology of the crista sellaris in *Trachemys scripta*

Prior to the formation and ossification of the mature braincase, the embryonic chondrocranium serves as an early cartilaginous model for cranium formation, around and within which the dermal and endochondral elements of the skull ossify, respectively. The crista sellaris, which ultimately ossifies to form the dorsum sellae in the mature skull, forms as structures in the orbital region of the chondrocranium unite with those of the braincase. Herein, the formation of the crista sellaris of the Red-eared Slider, *Trachemys scripta* (Testudines: Emydidae), is described and several hypotheses suggesting the relative timing and formation of the crista sellaris in three other taxa (*Chelydra serpentina*, *Chrysemys picta*, and *Caretta caretta*) are evaluated. Descriptions are based on cleared and double-stained embryos and serially-sectioned embryos that were incubated in the lab. These specimens allowed for evaluation of the developmental morphology of the trabeculae cranii, interorbital septum, pila metoptica, taenia marginalis, posterior orbital cartilage, pila antotica, parachordal cartilages, and crista sellaris. In *T. scripta*, the dorsomedial margin of the posterior orbital cartilage undergoes significant resorption, and the formation of the crista sellaris appears to be a result, at least in part, of retention of the remaining ventral margin of this structure. This pattern of formation appears to be similar to that seen in *C. serpentina*, and *C. caretta*. **SSAR SEIBERT MORPHOLOGY & PHYSIOLOGY**

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Feeding through contrasting hydrodynamic regimes: Prey capture performance in larval and juvenile teleost fish

It is well known that fish larvae and their juvenile / adult conspecifics live in two contrasting hydrodynamic regimes. To explore the consequences of changes in Reynolds Numbers fish operate in during ontogeny, we compared the kinematics of prey capture in larvae and juveniles of the teleost fish, *Sciaenops ocellatus*. Free swimming larvae and juveniles were filmed at 500 frames per second while feeding on plankton (larvae) and prey fish (juveniles) using a digital high speed video camera. Videos were played back frame by frame and we measured kinematic excursions and timing during key feeding events (mouth opening, hyoid depression, cranial rotation and the time to reach peak gape, hyoid depression and head rotation). Although kinematic variables had very little variation within each life history stage (larva or juvenile), there was a considerable change in the magnitude and timing of feeding kinematic events between larval and juvenile red drum. It appears that larvae were slower than their juvenile conspecifics. It is hypothesized that the relatively slower jaw

movements in larvae is associated with the relatively higher viscosity of water these small fish live in. Results of this study suggests that major changes in the physical nature of the environment during ontogeny affects performance traits in teleosts such as how they capture prey.

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Impacts of an introduced lizard, *Anolis sagrei*, on a simple Florida food web

Biological invasions result in the insertion of a novel species into the food web of an invaded community. Trophic interactions between the invading and existing food web elements can directly or indirectly affect native species by altering both food web structure and dynamics, and may ultimately produce changes in both species abundances and community composition. The incidence and severity of these food web effects will likely be greater for invaders with high population densities or biomass. Where highly abundant invaders cannot or will not be controlled or eradicated, food web studies should be conducted to determine the ecological impacts of invasion and to help prioritize management efforts. I describe an investigation currently underway to assess the impacts of brown anole (*Anolis sagrei*) invasion on the food webs of disturbed and human-modified Florida habitats, using a series of small islands as an experimental system. Since this introduced lizard can quickly become extremely abundant when it invades both the experimental islands and the disturbed/modified mainland areas they represent, it may reasonably be expected to directly and indirectly affect other organisms in these invaded food webs. Using arthropod community composition and abundances to measure impact, I am comparing islands where *A. sagrei* populations have been experimentally removed to both invaded and uninvaded control islands. *Anolis sagrei* has already successfully invaded several countries and U.S. states, and will very likely show up in others in the near future. If *A. sagrei* has large or undesirable impacts in Florida communities, the results of this study may provide justification for quick eradication of newly introduced *A. sagrei* populations elsewhere in the world, before such a task becomes impossible.

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Evaluating 50 years of anthropogenic impacts on an important Louisiana estuary using stable isotopes

Determining the effects of natural and anthropogenic disturbances on resource availability and food web interactions for fishes in open, highly-variable aquatic ecosystems is particularly difficult due to their mobility. Lake Pontchartrain, an oligohaline estuary in southeastern Louisiana, has been subject to numerous anthropogenic impacts over the last half century including runoff, shell dredging, over-fishing, saltwater and freshwater inputs, shoreline alteration, and

industrial discharges. Our recent work has focused on fish assemblage dynamics in Lake Pontchartrain over the past 50 years and results indicate that some have changed considerably. Here we utilize archived (formalin/ethanol preserved) samples of 2 abundant species of fishes (*Anchoa mitchilli*, n=225, *Micropogonias undulatus*, n=224) occurring within Lake Pontchartrain over the past 50 years. Samples of fishes collected from 5 previously described eco-regions in summer (May-July) of 1955, 1978, and 2001, which pre and postdate anthropogenic degradation, were utilized in the present study. We analyzed stable isotope ratios (C13/12, N15/14) using recently-developed techniques for preserved specimens. Results demonstrate that although considerable anthropogenic modification has occurred in this ecosystem over the past 50 years, levels of ¹³C across spatial and temporal scales were not significantly different, indicating that sources of organic matter in this economically and ecologically important estuary may have remained stable. However, significant changes in ¹⁵N reflect a reduction in trophic position from 1955 through 1978 and a return to previous levels between 1978 and 2001, suggesting shifts in food chain length throughout various levels of the food web whether caused by natural or anthropogenic events. Analogous results were identified in both a planktivore and an omnivore, indicating that the results obtained may be indicative of species with different life histories. Comparisons with a recent survey of sources of organic matter in Lake Pontchartrain and utilization of mixing models for retrospectively projecting carbon sources will be discussed.

***TYMINSKI, JOHN P.; GELSLEICHTER, JAMES**

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Cloning the androgen receptor protein in the Bonnethead Shark (*Sphyrna tiburo*)

Steroid hormones are essential for proper reproductive development in all vertebrates. Androgens are sex steroids secreted by the gonads that regulate virilization, spermatogenesis, and sexual behavior. These physiological actions require the binding of androgen to a specific receptor protein. Androgen receptors (AR) are ligand-activated transcription factors that bind to a specific nucleotide sequence of DNA and positively or negatively regulate transcription. Knowledge of these receptors in elasmobranch fishes, being the oldest living animals that possess an archetypical vertebrate pattern of reproductive endocrinology, may provide insight into the evolution of steroid hormone receptors in general. An understanding of the distribution and levels of expression of the elasmobranch ARs on the cellular and tissue level demonstrates the pattern of responsiveness to the androgenic hormones. In order to assess this distribution using molecular methods, efforts were initiated to clone and sequence a fragment of this gene in the bonnethead shark, *Sphyrna tiburo*, an elasmobranch species with a well-defined annual reproductive cycle. Degenerate primers were utilized in a nested PCR reaction to amplify a 325-base pair fragment from reverse-transcribed testicular bonnethead RNA. This fragment was ligated into a plasmid vector and transformed into competent *E. coli* cells. After growing transformants in liquid sub-culture, plasmid DNA was extracted and cut with a restriction endonuclease to confirm the presence of an appropriately sized insert. Sequencing of the plasmid/insert and subsequent analysis by BLASTX confirmed the identity of the insert as AR. This sequence

most closely resembled that of an amphibian (*Xenopus laevis*) and a bird (*Gallus gallus*). In future, the cloned AR fragment will be used to construct an RNA probe to characterize AR gene expression in this species using in situ hybridization (ISH) and northern blotting techniques which should lead to a greater understanding of the functional role of androgenic hormones in elasmobranchs.

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Relative abundance and long-term movement patterns of juvenile blacktip sharks, *Carcharhinus limbatus*, in three Florida Gulf coastal nursery areas, 1995-2004

The decline in recent decades of many U.S. shark stocks has led to the implementation of management plans with the goal of stock recovery. Because fishery-independent surveys are a valuable source of data to assess stock decline or recovery, the Mote Center for Shark Research initiated surveys in 1995, in three Florida Gulf coast nurseries (Yankeetown, lower Tampa Bay and Pine Island Sound), to estimate the relative abundance of juvenile blacktip sharks, *Carcharhinus limbatus*, a key species in the U.S. southeast commercial and recreational fishery. Monthly, random stratified sampling by bottom gill net was conducted within two geographically fixed 10 km² grids for each of the three areas which were selected based upon the consistent blacktip catches observed during previous exploratory studies. All shark catch was identified, sexed, categorized by maturity, measured and weighed, and all live sharks were tagged and released. A total of 970 quantitative gill nets sets were made between 1995 and 2004 resulting in the capture of 8,257 sharks of thirteen species, of which 3,842 were juvenile blacktips. Recaptures have been reported from 149 of the tagged sharks comprising 5 species. First-year blacktips have demonstrated movements of more than 280 nautical miles after leaving their summer nursery grounds. Recapture data further indicates a pattern of sharks returning to their natal nursery areas the following season and in subsequent years. A general linear model was used to standardize the CPUE data. Significant differences in the juvenile blacktip catch were found between years, nursery areas, and between grids within a nursery area. When looking at the blacktip catch rates over the entire 10-year period, there were no apparent trends that would be indicative of population level changes. Possible reasons for this lack of a clear trend as well as other relevant aspects of this dataset will be discussed.

***UGARTE, CRISTINA A.; BASS, ORON; MAZZOTTI, FRANK; RICE, KEN G.**

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American Alligator nesting effort and hatching success (1985-2004) in Everglades National Park using systematic reconnaissance flights

Systematic Reconnaissance Flights (SRF) have been used from 1985-2004 to monitor nesting effort and hatching success of the American Alligator in Everglades National Park. Because Everglades restoration in South Florida will modify the quantity, timing, distribution, and flow of water on an ecosystem-wide scale, SRFs, can be a useful tool to detect landscape-level changes in alligator nesting in response to hydrologic change. We assess relationships among hydrological stage data, abundance and distribution of alligator nests from 19 years of monitoring. A total of 1,087 nests were counted along 25 variable length line transects, 82 % of nests occurred in Shark River Slough (SRS) and North East Shark Slough (NESRS). There were fewer annual nests produced when March-April water levels were low. Spacing of nests varied across years, in most years, nests were clumped. Average March water stage (feet) was negatively related to the mean to variance ratio, this suggests greater clumping of nests when water was generally high in March. Annual nesting probability was greater in the longer hydroperiod regions of the slough than in shorter hydroperiod regions. Hatching success also varied annually, ranging from 22.0% to 90.0%. Although nesting effort and success can be partially explained by hydrological conditions, individual female behavior and local-scale topographic variation may be responsible for the unexplained variation among nesting effort, success, and hydrology.

UNMACK, PETER J.

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Extensive introgression in Australian rainbowfishes: Identification, patterns, implications, and misleading phylogenetic influence

Introgression is increasingly being recognized as having a greater influence than previously appreciated in the evolution of fishes. Early evidence for natural hybridization was mostly restricted to F1 hybrids, often with little or no evidence for introgression between the parental species. The introduction of molecular analyses has begun to change this perception, with several groups showing evidence of mtDNA introgression including various Catostomidae, Cyprinidae, Cyprinodontidae, and other families. This study focuses on rainbowfishes (Melanotaeniidae), one of several dominant groups in Australian and New Guinea freshwaters. Rainbowfish hybridization was considered to be rare in natural populations due to extensive sympatry and the examination of

thousands of specimens. The first mtDNA analysis found only limited evidence for hybridization within two species. Expansion of this work, based on mitochondrial cytochrome b and introns of the nuclear S7 gene has revealed evidence for extensive mtDNA introgression involving at least 10 of the 12 Australian *Melanotaenia* species. Introgressed populations from northwestern Australia were identified by the presence of mtDNA haplotypes from a sympatric species, whereas S7 haplotypes from the same specimens always formed monophyletic species-specific lineages that were strongly supported by bootstrapping. Numerous introgressed rainbowfish populations were identified, with some showing evidence of multiple introgressed haplotypes, suggesting either multiple hybrid origins, or post-introgressive evolution. For the most part, these introgressions appear to be short-term genetic influences, as no species appears to have completely lost its original mtDNA genome. However, one species has an introgressed mtDNA genome that has become extremely widespread and has clearly persisted for a longer time frame than other introgressions. Northwestern Australia provides a fascinating history of the evolution of rainbowfishes, and offers currently unparalleled opportunities for studying various aspects of introgressive hybridization, fitness differences of mtDNA genomes, sexual selection, and influences and limits to species reproductive boundaries. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

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The reproductive biology of *Vincentia conspersa* (Teleostei, Apogonidae): Another apogonid with direct development

Vincentia conspersa is a marine apogonid with a geographic range restricted to southern Australia, Tasmania, and off northern Tasmania. Very little is known about any aspects of its natural history, including its reproductive habits. Preliminary results of reproductive studies carried out during the last two years are reported. Under laboratory conditions, *V. conspersa* reproduced during both the winter and summer months. Courtship displays were brief, and mating occurred during day time. Only males incubated (orally) the clutch, which consisted of between 140 and 200 eggs. The eggs were held together by labile chorionic filaments and showed a large intraclutch size variation, ranging from 3 to 4.5 mm in diameter. As expected, there was a large variation in embryo development time in accordance with the temperature. For instance, flexion stage was reached after 18 days at 19 °C, and at 34 days at 14 °C. Embryos hatched as eleutheroembryos with large yolk sacs containing a characteristic very large oil globule that persisted until the end of yolk reabsorption. This occurred about a week after hatching, and then juveniles began exogenous feeding and swimming. Direct development, a highly unusual reproductive mechanism among marine teleosts, has been reported in only one other apogonid species, *Pterapogon kauderni*. This threatened species is restricted to the Banggai Archipelago in Indonesia, and produced eggs of 2.7-3 mm in diameter. In addition, at least two other species, *Apogon rueppellii* and *Cheilodipterus lineatus*, were reported producing eggs between 2 and 2.5 mm, which are significantly larger than the eggs produced by most apogonid species, with a size range between 0.2 and 0.6 mm. The phylogenetic relationships within Apogonidae are still poorly understood and based mainly on osteological characters. The use of

ontogenetic information could be valuable in helping to elucidate such relationships.

***VALENZUELA, NICOLE; EZAZ, TARIQ; BURKE, RUSSELL; GRUETZNER, FRANK; GEORGES, ARTHUR; MARSHALL GRAVES, JENNIFER**

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Identification of sex chromosomes in *Chelodina longicollis*: Karyotype revisited

Incubation experiments at a range of temperatures have demonstrated that *Chelodina longicollis*, a freshwater turtle inhabiting Australia, has genotypic sex determination, but the only previously existing karyotyping study found no distinguishable sex chromosomes. Our initial experiment of comparative genome hybridization (CGH) using chromosomal painting techniques (FISH) indicate that *C. longicollis* has an XX/XY system of chromosomal sex determination involving a pair of microchromosomes. This work supports the idea that species with otherwise homomorphic chromosomes and genotypic sex determination have cryptic sex chromosomes, where insufficient time has elapsed for mutational degeneration of heterogenous chromosomes (recombination is suppressed). We are currently carrying out additional experiments involving more individuals from different populations to establish the chromosomal sex determining system in *C. longicollis* conclusively. Existing information on the karyotypic number in *C. longicollis* is also revisited. Evolutionary implications of these results are discussed.

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Comparative gene expression of multiple sex-determining genes in TSD and GSD turtles

Expression of genes related to sex differentiation in turtles has been studied for one or a few genes and in a single TSD species at a time, providing a limited picture of the regulatory network associated with gonadal differentiation in thermosensitive taxa. Here we present results from a more encompassing analysis of gene expression comparing profiles of six genes related to sex differentiation (Aromatase, DAX1, DMRT1, SF1, SOX9, WT1) during the development of TSD (*Chrysemys picta*) and GSD (*Apalone mutica*) turtle embryos incubated under identical conditions. Implications for understanding temperature-dependent and genotypic sex determination in reptiles are discussed.

VASCONCELOS, WILLIAM RANGEL; *HRBEK, TOMAS; DA SILVEIRA, RONIS; DE THOISY, BENOIT; REBÊLO, GEORGE HENRIQUE; MARIONI, BORIS; FARIAS, IZENI PIRES

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Population genetic analysis of *Caiman crocodilus* (Linnaeus, 1758) and *Melanosuchus niger* (Spix, 1825) from South America

The genetic structure of *Caiman crocodilus* and *Melanosuchus niger* was investigated using a mtDNA fragment encompassing nearly complete cytochrome b gene and 3' flanking region. Inferences were based on a sample of 125 individuals of *C. crocodilus* from nine collecting localities in Peru, Brazil and French Guiana, and 132 individuals of *M. niger* from 11 collecting localities from Ecuador, Peru, Brazil and French Guiana. Several localities of both species show statistically significant mutation-drift genetic disequilibrium which supports the hypothesis of demographic expansion. Differentiation between the Amazon basin and extra-Amazon basin localities is significant; however, inference drawn from Nested Clade Analysis cannot distinguish between continuous range expansion, long distance dispersal or past fragmentation. Past fragmentation is also unlikely due to low number of mutational steps separating the two areas. Differences between the Amazon basin and extra-Amazon basin localities are potentially maintained by the reduced ability of *C. crocodilus* and *M. niger* to cross salt water barriers. Within the Amazon basin, continuous range expansion without isolation-by-distance is the most likely explanation for the observed structuring of genetic diversity in *C. crocodilus*, and isolation-by-distance is a likely structuring factor among *M. niger* localities. Differentiation also exists between black water and white water localities of both species.

VASSILOPOULOU, VASSILIKI

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Condition measures of a deep-sea flatfish as indicators of habitat quality in north-eastern Mediterranean waters

Biological measures of condition (condition factor (K), hepatosomatic index (HSI), gonadosomatic index (GSI), stomach fullness index (SF)) as well as biochemical measures (lipid content in muscle (L)) were compared among seasons, sexes, body lengths and maturity stages of four-spotted megrim (*Lepidorhombus boscii*), in order to investigate the state of the stock in the

oligotrophic Aegean Sea. Comparisons were made using a non-parametric Kruskal-Wallis ANOVA, and Tukey honest significant difference (HSD) test was applied for post hoc comparisons of significant effects. The condition factor (K) did not exhibit substantial differences, while GSI and HSI displayed significant variations. An inverse relationship appeared to exist between the latter two indices, with GSI presenting its highest values in early spring, coinciding with the peak spawning period for megrim, when HSI displayed minima. Lowest fat content percentages were observed during winter and then spring, a period also characterized by lowest feeding intake as suggested by SF values, although the latter index displayed low values in almost all cases, reflecting the poor feeding conditions in the study area. Fat reserves in the flesh of males (L), as well as energy storage in the liver of males, mirrored by HSI, were in almost all cases greater than in females. Lipid accumulation seemed to be positively related to size in males, while no such trend appeared for GSI and HSI. In females, all measures of condition did not seem to be functions of specimen size, although during the spawning period largest females displayed the lowest accumulation of lipids in their flesh. Our results reveal the poor condition of specimens, particularly females, in the Aegean Sea, indicating possibly the low quality of the habitat in the area, that could be also connected to the observed limited growth and fecundity of the species there.

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Distribution, taxonomy, and natural history of the Central American toads of the Genus *Crepidophryne* (Anura: Bufonidae)

We review the taxonomic status of all known populations of toads referred to *Crepidophryne epiotica* (Cope, 1875) and summarize what little is known about their distribution and ecology. Morphological comparisons of museum specimens indicate that the toads actually represent a complex of 3 or 4 species, that are scattered allopatrically in the uplands of Costa Rica and western Panama.

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Fish species in Yucatan Peninsula coast

Because its karstic soil, Yucatan peninsula is characterized by subterranean flows and springs which are connected to the open sea where a variety of fish species live and interact. In this study we sampled thirty eight sites on cienegas, petenes mangroves and freshwater seeps using a beach seine (3 x 1 m) and a drop net (1.5 diameter) to evaluate fish species composition and spatial pattern of species richness. Some ecological aspects such as salinity tolerance and diversity (beta and gamma) were considered. Multivariate analyses were carried out for species

composition and assemblages. Twenty eight species were recorded and on the basis of presence and occurrence, habitats were separated in two great groups: a) cienegas and salty ponds and b) petenes and freshwater seeps. In the first group, catches consisted predominantly of *Gambusia yucatana yucatana*, *Poecilia velifera* and *Cyprinodon artifrons*, which are the most widely, distributed species. In natural springs, Characidae (*Astyanax aeneus*, *A. altior*), Cichlidae ("*Cichlasoma octofasciatum*, *Thorichthys meeki*) and Pimelodidae (*Rhamdia guatemalensis*) families were most representative. The high diversity and species richness in cienegas and salty ponds suggest that these habitats are important nursery grounds for numerous marine euryhaline species. As an important contribution to fish vulnerability, we recorded *Cyprinodon labiosus* in Progreso, Yucatan, an endemic species from Chichancanb, Quintana Roo.

VICE, DANIEL S.

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Large scale management of an invasive reptile: Brown Treesnake control on Guam

The invasive brown treesnake (*Boiga irregularis*; BTS) is responsible for catastrophic losses to economic and biological resources on the island of Guam, including the extirpation of nearly all native forest birds and lizards, disruption to island electrical distribution networks, and numerous life-threatening bites on infants. The secretive nature of the abundant snake, coupled with the importance of Guam as a primary shipping hub in the western Pacific, has led to BTS dispersal via outbound cargo to locations throughout the world. Management of the snake has developed incrementally over 20 years, facilitated by extensive research into BTS biology and control methods. The primary objectives of control programs, including the prevention of dispersal from Guam and the protection of island resources, are accomplished via trapping, hand capture, detector dogs, toxicants, prey-base reduction, and physical barriers. Through the integration of these control measures, the federal BTS interdiction program has removed nearly 40,000 snakes from outbound cargo operations over the previous 9 years. Despite limitations, operational work appears to be reducing snake dispersal and recovery efforts native wildlife are progressing. Long term program success is dependent upon the continuation of current activities, as well as the development and implementation of new control methods.

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Recovery of native lizards on a Micronesian atoll

Guam's fragile island ecosystem has been devastated by human-mediated arrivals of invasive species. The earliest Carolinian settlers introduced plants and animals as supplemental food sources, and today, new species continue to arrive via intentional and unintentional human introductions. The effects of introduced species on Guam have created complex problems for native wildlife. The

introduced brown treesnake (*Boiga irregularis*) is responsible for the most dramatic impacts, including the loss of most native terrestrial vertebrates from the island. Enormous populations of introduced lizards compete with native lizards for resources and support the snake population. The superabundant snake, in turn, suppresses native lizard populations. Cocos Island, a 38-hectare island located 2.4 km off the southern tip of Guam, supports remnant populations of Guam's native lizards and birds. The island was considered snake-free, however, recent snake sightings indicate Cocos Island's snake-free status may be in jeopardy. Trapping efforts intended to identify incipient brown treesnake populations have captured no snakes; however, nearly 600 incidental captures of rodents and monitor lizards (*Varanus indicus*) reduce the validity of survey results. Planned rodent eradication on Cocos Island will facilitate the detection, and potentially, eradication, of incipient snake populations. Initial conservation efforts on Cocos Island will document the lizard assemblage prior to rodent eradication, as well as forest and seabird populations. Bio-security protocols for people and cargo arriving on Cocos will be implemented prior to the onset of management activities. To protect the island from typhoon damages, native tree species will be planted, and invasive plant species will be removed. Following rodent eradication and snake control efforts, released native forest birds and native lizard populations will be monitored. Trilingual interpretive signs will provide information to visitors.

***VICTORIANO, PEDRO F.; ORTIZ, JUAN CARLOS**

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A multivariate analysis of taxonomic limits in species of the genus *Diplolaemus* (Squamata; Leiosauridae)

The genus *Diplolaemus* Bell, 1843 is a typical reptilian component of the Patagonian Province. Considerable taxonomic confusion exist within this genus, particularly about the status of Chilean-Andean populations and about the actual distribution of *D. leopardinus* (Werner, 1898). In an attempt to clarify the taxonomic limits among populations we performed a principal component analysis (PCA) and discriminant function analysis (DFA) using both standard morphometric and meristic measurements. Morphometric results demonstrated that most species are poorly discriminated with the exception of *D. darwini*. In contrast a PCA performed on a combination of scalation measurements clearly distinguished three groups: 1. *D. darwini*, 2. *D. sexcinctus* including the Chilean populations, and 3. Mendocine populations including the holotype of *D. leopardinus* and part of *D. bibroni*. The DFA consistently assigned with a high percentage of successful classification (> 97%) individuals of the species *D. darwini*, *D. sexcinctus* and *D. bibroni*. The group with lowest successful rate in the cross validation procedure (84%) was *D. leopardinus* (including Mendocine populations), with misidentifications assigned only to *D. bibroni*. The Mendocine populations + *D. leopardinus* holotype group are visible distinct from the *D. bibroni* in colour patterns. The holotype of *D. leopardinus* is clearly differentiated from the Chilean-Andean populations and is nested with the Mendocine group. Our results support the assignment of Mendocine populations to *D. leopardinus*, suggesting that the Chilean-Andean populations must be included in *D. sexcinctus*. Molecular results are required to test these findings. Suport. Proys. DIUC 92.38.24-1 / 96.113.040-1.

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Comparative phylogeography of three co-distributed species of *Liolaemus* (Tropiduridae) from South-Central Chile

Liolaemus Wiegmann, 1834, is the most common lizard genus in Chile with 42 species. This genus is represented by several endemic species within Chile, presumably a result of the isolating effects of the uplift of the Andes, effectively isolating Chilean taxa from Argentinian congeners. The high richness of species and the high intraspecific variation frequently observed in morphological features, suggest that this genus has been a dynamic group in an evolutionary sense and it has likely speciated extensively as a response to recent and ancient tectonic and climatic changes in this part of South America. However, the microevolutionary history within the genus is poorly understood. We selected three co-distributed species from South-Central Chile (*L. tenuis*, *L. lemniscatus* and *L. pictus*) for a comparative study of phylogeography, to test hypotheses about evolutionary processes involved within their geographic range. We expect similar phylogeographic patterns among populations of each species. By using mitochondrial DNA sequences (Cyt-b and 12S), we have recovered hypotheses of evolutionary relationships of these three species. Sequences were used to implement Nested Clade Analyses(NCA). Nested clade distance measures were tested for associations with geographic locations, and an inference key then followed to derive a plausible biological cause (range expansion, fragmentation or reduced gene flow). The combined data set for all sequenced gene regions were used for traditional phylogenetic analyses (Maximum Parsimony, Maximum Likelihood, and Bayesian), using two outgroups (chilean species *L. chilensis* and *L. monticola*). The results are discussed with respect to the existing palaeoclimatic and palaeotectonic data from South-Central Chile. Suport.DIUC 203.113.064-1.0

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Higher-level relationships of alethinophidian snakes

According to recent molecular studies, the monophyletic alethinophidian snakes include 6 main groupings : 1) pipe snakes (Aniliidae) and tropes (Tropidophiidae), 2) boas (Boidae including Erycinae and Ungaliophiinae) and African burrowing pythons (Calabariidae), 3) pythons (Pythonidae), Mexican burrowing pythons (Loxocemidae) and sunbeam snakes (Xenopeltidae), 4) Round Island boas (Bolyeriidae), 5) Asian pipe snakes (Cylindrophiiidae), dwarf

pipe snakes (Anomochilidae), and shield-tail snakes (Uropeltidae), and 6) advanced snakes (Caenophidia). The resolution of the interrelationships among these 6 lineages is required in order to infer the evolution of the lifestyle and feeding mode of snakes as well as their biogeography. We address these questions using new DNA sequences obtained from several nuclear and mitochondrial genes.

***VIEITES, DAVID; NIETO-ROMÁN, SANDRA**

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Do females lose control? Post-mating clutch piracy in frogs

The study of genetic mating systems has led to the discovery of new alternative reproductive strategies in different animal groups, some of them resulting in multiple paternity processes. The typical mode of reproduction for extant anurans is amplexus, where a male physically grasps a female and the pair deposits one spherical clutch of eggs. We have described a new mating strategy in frogs, that we call clutch piracy. The strategy consists of post mating clutch re-fertilizations by non-amplecting males, without the presence of the female but only the clutch, resulting in multiple paternity. Also, size-assortative mating suggests the existence of sexual selection in the studied population. This implies that this strategy weakens the impact of sexual selection. We will present new data on this behaviour and discuss the impact of this strategy on sexual selection and the fitness of males and females. It is unclear how common clutch piracy is in anurans and this species, but the report of this strategy in two other species of frogs encourages for more research on this system.

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Reducing size, weight, and time drift of Frogloggers using digital recorders and microprocessors

The Automated Recording System (also known as Frogloggers) suffer from several limitations due to the technology used. Analog cassette recordings are limited to up to 90 minutes of recording. The recordings in a cassette take a lot of time to transfer to a computer for archival and analysis. The solid-state timers used are expensive and have a high drift in time. I've designed a controller using a low cost and low power microprocessor coupled with a quartz crystal that reduces to a negligible amount the drift in time. Since the controller is programmed using custom software, the sampling periods can be customized for each site and hypothesis being tested. The controller can be used to trigger several models of digital recorders, including Hi-MiniDiscs recorders and the Marantz PMD670 solid state recorder. These recorders can store the sounds in 16-bit wav files using a sampling rate of 44.1 kHz. Most of these combinations are smaller and lighter than the cassette based Frogloggers. In addition, the

recordings can be easily transferred to a computer for analysis.

***VILLANUEVA-RIVERA, LUIS J.; ACEVEDO, MIGUEL A.**

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Automated digital recording systems as effective tools for the monitoring of tropical vertebrates

There is a need to improve the quantity and quality of data in monitoring projects. We compared a new automated digital recording system (ADRS) with traditional methods, point-counts and transects, to determine presence/absence of birds and amphibians, respectively, in a forested wetland in Puerto Rico. To our knowledge, this is the first time an automated recorder has been tested with survey methods, and in particular in a tropical region. With the ADRS we obtained a higher number of species in each point than with traditional surveys. This new method has three additional advantages: permanent record of a census, 24 hours per day data collection and the possibility of automated species identification. This method has applications for long-term and large-scale monitoring projects, particularly at high diversity areas like tropical forests.

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MHC-based kin recognition in African clawed frog tadpoles

Kin-recognition abilities, first demonstrated 25 years ago in toad tadpoles, now appear to be widespread among amphibians. South African clawed frog (*Xenopus laevis*) tadpoles preferentially school with kin over non-kin even if unfamiliar with both. Kin recognition in fishes, rodents, and even humans makes use of highly polymorphic Major Histocompatibility Complex (MHC) genes. We tested whether *X. laevis* tadpoles discriminated among siblings based on shared alleles at the MHC class-1a locus. We determined MHC haplotypes by the polymerase chain reaction using sequence-specific primers (SSP-PCR). By mating MHC-heterozygous parents, we obtained families of full siblings that shared variable numbers of MHC alleles. We tested tadpoles for their preferences to associate with particular siblings based on numbers of MHC alleles that they shared. MHC-homozygous subjects preferentially schooled with stimulus groups with which they shared two MHC alleles over those with which they shared one or no MHC alleles. However, MHC-heterozygous subjects did not discriminate between siblings with which they shared one or two MHC alleles, and MHC-homozygous test subjects did not discriminate between siblings with which they shared one or no MHC alleles. We conclude that the observed MHC-linked schooling preferences are based on allelic differences rather than similarities. We found exceptionally high levels of MHC polymorphism within wild *X. laevis* populations. Hence, a recognition system based on the MHC or closely linked genes should be sufficient for kin discrimination. MHC-based discrimination may be retained through ontogeny and thus may serve to maintain MHC polymorphisms by facilitating disassortative mating.

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Herpetofauna of the Jalapão region of the Brazilian Cerrado

Located in the eastern part of the state of Tocantins and in parts of western Piauí and Maranhão, the Jalapão region covers approximately 53,340 square kilometers of relatively undisturbed Brazilian cerrado. We used pitfall arrays, drift fences with funnel traps, and hoop net traps, and we searched habitats, excavated termite nests, and visited aquatic habitats at night to determine species composition and relative abundance of reptiles and amphibians of Jalapão. At minimum, the herpetofauna is comprised of 109 species in 22 families including caecilians (1 family, 1 species), frogs (4 families, 32 species), turtles (1 family, 1 species), crocodylians (1 family, 2 species), lizards (9 families, 26 species), and snakes (6 families, 47 species). Some species remain undescribed. Most of the herpetofauna is typical of the Cerrado, although a few species typically found in Caatinga were present.

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Identifying the contribution of hybridization between two toad species (Genus: *Bufo*) to the decline of a parental species

Habitat disturbance leading to the breakdown of ecological barriers between sympatric species has resulted in hybridization between numerous plant and animal species and contributed to the decline or extinction of one or both parental species. Toads of the genus *Bufo* are known to hybridize where species ranges overlap, although differing habitat requirements generally function as an effective barrier to gene exchange. In Louisiana, there are four toad species that may produce a majority of viable and fertile hybrid offspring in areas of sympatry. Hybrids resulting from crossing a female of any of these species and a male, *B. nebulifer*, are invariably infertile males, while the reciprocal cross results in complete inviability. Despite strong postzygotic selection against it, hybridization occurs between two normally ecologically isolated species, *B. nebulifer* and *B. woodhousii*, as a result of anthropogenic habitat alteration. This hybridization is potentially resulting in a decline of the rarer species, *B. woodhousii*. Hybrids of the two species are morphologically cryptic; therefore, molecular methods were used to identify them. Single nucleotide polymorphisms (SNPs) are a recent technique utilized to identify hybrids that cannot be conclusively identified by morphological characteristics alone. Twelve species-specific SNPs from a 660 base pair fragment in a nuclear intron of the Rhodopsin gene were used to identify each species, and hybrids were identified

based on heterozygosity at these sites. Fifty-two individuals from five mixed breeding populations currently have been directly sequenced and two male hybrids of *B. nebulifer* and *B. woodhousii* were identified. Although hybrids represent a relatively low segment of the sample population, directional hybridization of male *B. nebulifer* with female *B. woodhousii*, as demonstrated by previous research, may be a historical factor in the decline of *B. woodhousii*. Furthermore, infertile male hybrids have been shown to preferentially mate with *B. woodhousii* females, potentially causing a devastating loss of gametes and reproductive effort in females of that species. **STOYE GENETICS, DEVELOPMENT & MORPHOLOGY**

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Predator-induced shifts in metamorphosis in response to larval and metamorph risk

Predation risk can cause organisms to alter their behavior, morphology, and the timing of life history switch points. Theoretical predictions suggest that, for a given resource availability, increased predation risk in an early life stage should select for switching earlier at a smaller size while increased risk in the subsequent stage should select for switching later and larger. This theoretical framework has frequently been applied to the timing of metamorphosis in amphibians, with mixed results. While a number of studies have examined the effect of increased larval predation risk on metamorphosis, only a few have observed the pattern predicted by theory. Furthermore, no studies, to our knowledge, have examined the effect of increased risk during and after metamorphosis on the timing of this switch point. In this study, we examine the effect of larval and post-metamorphic predation risk on metamorphosis in the red-eyed treefrog, *Agalychnis callidryas*. We conducted a 2 x 2 factorial experiment in which tadpoles were raised in the presence or absence of cues from caged water bugs (*Belostoma* sp.) fed tadpoles and spiders (*Thaumasia* sp.) fed emerging metamorphs. Both predators are common at *A. callidryas* breeding sites. Water bugs are effective tadpole predators while spiders are poor tadpole predators but prey on metamorphs. Furthermore, since spiders forage on the water surface it is possible tadpoles could assess future risk from this predator. Both predators induced life history shifts in the direction predicted by theory. Tadpoles metamorphosed earlier at smaller sizes in response to water bugs, but metamorphosed later and larger in response to spiders. Switching early in response to water bugs may increase survival by reducing exposure to larval predation. Switching later in the presence of spiders may enable frogs to reach a larger size before encountering this predator, increasing their probability of escape.

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Evidence of disruption of osmotic and ionic regulation in *Bufo woodhouseii* infected with *Batrachochytrium dendrobatidis*

The fungal pathogen *Batrachochytridium dendrobatidis* is suspected to be the proximate cause of mass die-offs of wild amphibian populations around the world. In the lab *B. dendrobatidis* has been proven by fulfillment of Koch's Postulates to be responsible for amphibian mortality, yet the mechanism by which it causes death is unknown. This chytrid fungus is commonly found in the epidermal layer of the ventral integument of infected amphibians. This region of skin is especially important for osmotic and ionic regulation. We designed a preliminary experiment to investigate the possibility that *B. dendrobatidis* might disrupt the regulatory mechanisms in amphibian integument. Field collected *Bufo woodhouseii* that tested positive for *B. dendrobatidis* using PCR analysis were monitored in the laboratory for symptoms of infection. We collected blood plasma and measured total solute concentration and concentrations of Na⁺, Mg⁺, K⁺ and Ca²⁺ using Atomic Emissions Spectrometry (AES). Dissected skin samples from toads with varying number of symptoms were mounted in a Ussing chamber and bathed in Ringer's solution. Ion transport was measured as the short-circuit current (I_{sc}) with a voltage clamp. Results indicate that toads with more symptoms had reduced rates of ion transport and significantly reduced plasma solute concentrations (p = 0.001) than asymptomatic toads. Decreases in Na⁺, Mg⁺ concentrations and significant reductions in K⁺ concentration (p = 0.003) at least partially contributed to the reduced plasma solute concentrations. There was no significant change in Ca²⁺ concentration. These data suggest that *B. dendrobatidis* may impair normal epidermal functioning and thereby alter blood ion concentrations. These alterations may be implicated in mortality associated with *B. dendrobatidis* as osmotic and ionic balance is critical physiological functioning.

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Movement and survival of treefrogs in four Everglades ecosystem habitats

Proposed management actions under the Comprehensive Everglades Restoration Plan (CERP) will alter the timing and amount of water flowing to natural areas throughout south Florida. Anurans may be useful as indicator species to gauge the success of these restoration efforts. Two species of treefrogs are readily captured in PVC pipe refugia in south Florida: green treefrogs (*Hyla cinerea*) and squirrel treefrogs (*Hyla squirella*). We monitored populations of these two species at six sites in Big Cypress National Preserve for one year. Each individual was uniquely marked and measured before release. Each site was divided into two or

three habitats that represent different hydropatterns. Movement rates between habitats within a site were estimated, as was survival and capture probability within habitats using multi-strata capture-mark-recapture models. Information-theoretic approaches to model selection and multi-model inference were used to choose the best model and parameter values. More than 1,500 individual green treefrogs and 1,000 squirrel treefrogs were captured across the six sites. Movement rates between habitats were generally low. Survival rates within a habitat appear to be time-dependent and may be influenced by hydrology and habitat. Capture probabilities are also time-dependent and are likely influenced by environmental conditions such as temperature and water depth. This research indicates that changes in abundance of anurans at sites undergoing hydrologic restoration will likely be explained by changes in survival or reproduction, not increased immigration. **SSAR SEIBERT ECOLOGY**

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New insights into feeding functional morphology from centrarchid fishes

Centrarchid fishes have enjoyed a rich history as workhorses of experimental functional morphology on fish feeding. This prominence can be attributed to the interesting ecological and morphological diversity contained within the group and the remarkable suitability of many centrarchid species to life as a laboratory subject in functional morphology. Here, I present results from two recent approaches designed to achieve deeper understanding of the implications of centrarchid morphological diversity for their ability to suction feeding. In the first case we have developed a model that relates variation in head morphology to the capacity to generate suction pressure. The model is based on the idea that suction pressure can be thought of as force exerted by the fish per unit area of the expanding buccal cavity and was validated with data on peak suction pressure generated by 45 individual centrarchids from five species. These results show that species with a high dorsal region and narrow buccal cavity generate strong suction pressure gradients. In the second area of research we are using digital particle image velocimetry to study the patterns of water flow that occur in front of suction feeding centrarchids. We have found that the area of affected water during suction feeding is severely restricted to the space immediately in front of the mouth. The velocity of water flow at a position one half of a mouth diameter away from the mouth is only 20 percent of that at the mouth and at one mouth diameter distance from the mouth it is less than 5 percent. The dimensions of the flow field are a function of the size of the mouth aperture and flow speed depends on the rate of mouth opening. These scaling relationships apply within and between species.

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Discovery of the first plethodontid salamander from Asia

Seventy percent of salamander species are plethodontids, a largely New World group which has only a few representatives of the otherwise Californian genus *Hydromantes* in the mid-Mediterranean region. We report the discovery of plethodontid salamanders in Korea. These salamanders are sufficiently distinct in morphological and molecular traits to warrant assignment to a new genus and species. Morphological differences between this species and putative relatives, preliminary analysis of phylogenetic relationships, and information on distribution and natural history will be presented and discussed. The new discovery necessitates modifications to hypotheses of plethodontid historical biogeography.

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Using automated radio telemetry to monitor Desert Tortoise (*Gopherus agassizii*) activity patterns

Automated radio telemetry equipment is currently being used to study the activity patterns of desert tortoises (*Gopherus agassizii*) at the National Training Center on Fort Irwin. This equipment can enable one person to monitor and document the activity of many animals continuously over an extended time, regardless of weather, light level or terrain. The basic approach is to record and analyze the radio signal received from a radio transmitter mounted on the study animal. Because of the directivity pattern of the transmitting antenna and the fact that variations in its juxtaposition to its surroundings change the radiated power, motion of the animal causes changes in the received signal. A recording of the temporal variation of the received signal contains considerable information about the movement of the animal. Interpretation of these signals is amenable to automated analysis by computer algorithms. Automated data analysis computer algorithms classify signals as active or inactive, based on moving averages of changing signal amplitude. Data from radio transmitted tortoises are being transferred real-time by radio signal to a web accessible relational database. Data storage is accomplished through a central database capable of storing all data collected and capable of being served on the web. Activity data, in conjunction with meteorological data, are being recorded to provide detailed temporal information on when tortoises are active above and below ground on a yearly basis. Data from this research project should benefit the recovery and

management of desert tortoise populations through refinements in a number of research areas, e.g., temperature-based tortoise handling guidelines, line distance sampling, baseline activity patterns, and translocation.

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Home range, movement patterns, and seasonal variation in habitat selection by canebrake rattlesnakes (*Crotalus horridus*) in South Carolina

Habitat structure and resource availability are two of the most important factors affecting animal movement patterns. The objectives of this study were to use radio telemetry to compare intraspecific differences in movement patterns, home range sizes, and seasonal variations in habitat selection by Canebrake Rattlesnakes (*Crotalus horridus*) in the South Carolina coastal plain. Home range estimates for each study animal were calculated using GPS positions of snake relocations. Rattlesnake locations were grouped into seasons based on behavioral observations of study animals, which included the foraging season (April through July), the breeding season (August through October), and the hibernation season (November through March). Movement patterns were quantified based on seasonal variation in both distance moved and number of movements. GIS-based habitat variables were recorded as use versus availability with a case-control sampling design. The average home range size for males was significantly larger than the estimate for non-gravid females. Repeated measures ANOVAs indicated that males moved significantly farther and more often during the breeding season than females. During the foraging season, males selected hardwood bottoms, whereas females selected pine hardwood forests. Male habitat selection during the breeding season shifted to fields, whereas females showed no significant breeding habitat association. However, both males and females selected pine hardwood forests during the hibernation season. Overall, male and female Canebrake Rattlesnakes partitioned habitat during the foraging season, when intraspecific competition for resources was expected to be most pronounced. **HL JAEGER**

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Population variation in behavior during encounters between hatchlings of the green anole and an invasive congener

In precocial species with short post-maturation life expectancies, early behavioral interactions may be especially important in determining the overall effect of interspecific competition. The range expansion of the invasive Cuban brown anole, *Anolis sagrei* (Sauria: Polychrotidae), in North America has occurred concurrently with an apparent decline in the abundance of the native green anole, *A. carolinensis*, but studies of adult interactions between these lizards have shown low interspecific behavioral interference and thus little evidence for competition. In the first interspecific test of agonistic behavior in sub-adult green

anoles, I staged laboratory encounters between equal-aged hatchling *A. carolinensis* and hatchling *A. sagrei* (age < 7 days). Hatchling *A. carolinensis* from a population within the introduced range of *A. sagrei* (Jacksonville, FL) were no less likely to display towards heterospecifics than towards conspecifics, but *A. carolinensis* from a population outside of the current range of *A. sagrei* (Augusta, GA) showed a much lower probability of display towards heterospecifics than towards conspecifics. Despite these population differences in *A. carolinensis* behavior, *A. sagrei* exhibited no difference in response and was much more likely to flee from an encounter or to be supplanted. In encounters in which hatchlings were size-matched (*A. carolinensis* age < 7 days; *A. sagrei* age < 30 days), however, the probability of *A. sagrei* flight or expulsion was much lower in encounters with *A. carolinensis* from the GA population, but not so in encounters with *A. carolinensis* from the FL population. Contrary to findings for adults, interactions escalating to attacks including biting, although rare, occurred with equal frequency among encounter types and with no asymmetry in direction. These findings indicate variable interactions with an invasive species and suggest that studies limited to adult behavior in a single population may be inadequate in fully characterizing such interspecific encounters.

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Management and conservation biology of yellow anacondas (*Eunectes notaeus*) in Argentina

Between 1980 and 1999 about 320,000 skins of Yellow Anaconda (*Eunectes notaeus*) were traded worldwide originated mainly in Argentina and Paraguay. In 2001, the governmental authorities of Argentina commanded us to design and implement a management program for the species. The program provided the tools to conceal the traditional use of a valuable resource with its conservation, with the additional benefit of allowing a deep research on the biology of the anacondas while testing specifically devised management strategies. Between 2002 and 2004 the program produced around 5,300 skins annually. Size distribution and sex composition of the cropped skins, as well as catch per unit effort and yield, remained constant along the first three years, indicating that harvest figures are within sustainable levels. Population parameters and reproductive cycles are, for the first time, presented for this species. Natural populations are comprised almost with adult size individuals with equal ratio male to female, suggesting high growing rates. Females can reach a maximum size of 330 cm SVL and approximately 30 kg of weight, while males rarely surpass 230 cm and 10 kg. Sexual maturity takes place at 130 cm SVL for males, while females are physiologically mature at 140 cm. However, female size at first reproduction is very variable depending on body condition and reproductive strategy, ranging from 142 cm to 255 cm SVL. Fecundity is positively correlated with female size. Reproductive frequency depends on female body condition (capital breeder), although the population studied averaged a biennial cycle. Diet composition suggests that yellow anacondas are opportunistic predators. The

assessed genetic structure of Formosa populations allowed us to identify two potential management units. A regulated, but overall low and scattered hunting effort distributed over a heterogeneous landscape, combined with biological traits emerging from dealing with a highly seasonal ecosystem, are factors that contributes to the sustainability of the crop in this yellow anaconda population.

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Further characterization of tumor cell growth inhibitory activity in epigonal conditioned medium (ECM) from bonnethead shark, *Sphyrna tiburo*

Previous work in our laboratory has demonstrated that media conditioned by short-term cultures of bonnethead shark (*Sphyrna tiburo*) epigonal cells (epigonal conditioned medium, ECM) possessed potent growth inhibitory activity against several tumor cell lines, including human malignant melanoma (A375.S2), murine fibrosarcoma (WEHI 164), breast carcinoma (MCF-7), and Burkitt's B-cell lymphoma (Daudi). Continued studies have focused on 1) characterization of preferential inhibition of ECM toward malignant versus non-malignant cells, and 2) isolation and purification of bioactive ECM proteins and peptides with increased specific activity. To evaluate the specificity of ECM for malignant cells, a normal/tumor cell line pair, derived from human primary ductal carcinoma (HCC38) and normal peripheral blood cells (HCC38 BL), was used. ECM demonstrated preferential cytotoxicity towards malignant cells, with approximately 2 to 4.5 times more growth inhibition of malignant cells than non-malignant cells. Efforts to purify bioactive compounds included application of crude ECM to Bio-Rex 70 cation exchange chromatography, with bioactivity residing in bound material eluted with 0.8 M NaCl. Further separation of the salt-eluted fraction using AcA 34 molecular exclusion chromatography resulted in protein fractions with approximately three-fold increase in bioactivity over that of crude ECM. Separation of ECM proteins based on hydrophobicity using reverse-phase C18 HPLC resulted in fractions with approximately 10 to 20-fold increase in growth inhibitory activity. Fractions with greatest bioactivity were subjected to in-liquid tryptic digestion, with resulting peptide fractions isolated by reverse-phase HPLC and assayed against human breast carcinoma cell line MDA-MB-435. Two fractions, shown by mass spectrometry to contain at least two unique peptides, demonstrated significant inhibitory activity at concentrations as low as 1.0 ug/ml, representing an approximately 500 to 1000-fold increase in specific activity compared with crude ECM.

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Does the Red-cockaded Woodpecker function as an umbrella species in the Winn Ranger District of Kisatchie National Forest, Louisiana?

The umbrella species concept is an important and widely used principle in modern conservation biology. An umbrella species is a species whose conservation confers a protective umbrella to numerous co-occurring species. The Red-cockaded Woodpecker (*Picooides borealis*) (RCW) fits the profile of an umbrella species, because they are endemic to the small remnants of fire-maintained pine forest of the southeast United States. Red-Cockaded Woodpecker habitat management may affect many species of co-occurrence especially herpetofauna. Thirty-four amphibian and 38 reptilian species are closely associated with longleaf pine habitat and 35% of all amphibians and reptiles inhabiting longleaf pine habitat were of concern to conservation agencies. The aim of this study was to look at how the current management of the RCW affects the herpetofauna inhabiting the same ecological niche and conclude from this information the umbrella species status of the Red-cockaded Woodpecker. I surveyed three managed RCW Improvement Stands that represent viable RCW habitat and two non-managed (control) areas representing non-viable RCW habitat for reptile and amphibian species richness and composition. A preliminary study indicated that the species richness was greater in non-managed habitat than managed and species composition was different between managed and non-managed habitat.

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Fish assemblages of the Apalachicola River floodplain in relation to altered hydrology

The Apalachicola River has the largest discharge of Florida rivers and has one of the most extensive forested floodplains of the Gulf Coastal Plain. Decades of regulated hydrology, long-term droughts, and increased water consumption have significantly affected aquatic habitats and fish communities in the floodplain and the river. Management agencies are in need of critical information in order to make informed decisions regarding allocation of water resources to restore and protect habitats and associated fish populations within this stressed system. Of particular concern are low-flow conditions and habitat availability during critical life-history phases of floodplain-dependent fishes. From 2001-2004, we surveyed fish populations in the forested floodplain in order to characterize and quantify current conditions and to evaluate hydrological impacts on aquatic habitats and communities. Emphasis was placed on semi-quantitative sampling of age-0 fish with light traps to estimate recruitment, spatial and temporal use of floodplain habitats, and to associate abundance with hydrological conditions. We collected approximately 37,000 larval fish in the floodplain and 5,000 in the main channel from 883 traps deployed for 12-hr periods, representing at least 50 species in 13 genera and 16 families. Cyprinids

and centrarchids dominated in both the floodplain and main channel, but species composition varied. *Notropis texanus*, *Lepomis macrochirus*, and *L. gulosus* made up 70% of larval fish collected in the floodplain, whereas the main channel was dominated by *Cyprinella venusta*, *Dorosoma petenense*, and *Carpionodes cyprinus*. Comparison of the results to historical data revealed changes in the relative abundance and composition of some species. These changes likely result from impairment of floodplain habitats via reduced river-floodplain connectivity and instances of degraded water quality. Diversity and capture rates were inconsistently correlated with several physicochemical parameters, likely due to variation in backwater micro-habitats and presence/absence of habitat specialists.

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Resilience of a pond-breeding amphibian community following mitigation of introduced fish

Introduced species constitute one of the most important anthropogenic impacts in many ecosystems, and the introduction of predaceous fish is implicated in amphibian population declines in many regions. Previous studies have documented the resilience of amphibian species following removal of introduced fish. However, no study to our knowledge has evaluated the amphibian community-level responses to such mitigation. We conducted a field experiment to investigate the effects of introduced fish on amphibian community dynamics and the resilience of an amphibian community following fish removal. This study was conducted at Warbler Woods Nature Preserve, a site under jurisdiction of the Illinois Department of Natural Resources. Introduced fish, present in two ponds prior to the commencement of this study, were removed via the application of Rotenone, a poison commonly used in fish management. To evaluate the resilience of the amphibian community following mitigation of fish introductions, we compared temporal shifts in amphibian species diversity within and between mitigated and reference ponds. Additionally, we examined the effects of introduced fish on smallmouth salamander larval period and growth. Our results indicate that mitigation of introduced fish improved amphibian species diversity, and that amphibian communities are particularly resilient following fish removal. Additionally, smallmouth salamander juvenile recruitment increased and the duration of the larval period was prolonged following fish removal. These results indicate the adverse effects of introduced species on native amphibians, as well as provide a better understanding of the roles of life history shifts in response to environmental variation.

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Same family, different tunes, a whole lotta love: Passive acoustic mapping of *Cynoscion nebulosus* and *Cynoscion arenarius* spawning sites in Tampa Bay

Hydrophones, a type of underwater microphone, can be used to detect and record spawning sounds of soniferous fishes. During their summer spawning season, mature male spotted seatrout, *Cynoscion nebulosus*, and sand seatrout, *Cynoscion arenarius*, generate species-specific sounds in the crepuscular and evening periods by vibrating sonic muscles against their swim bladders. Because these calls are associated with courtship, spawning sites can be located based on sound production throughout a sampling area. A total of 849 locations in Tampa Bay were selected using a stratified random sampling design and were sampled with a mobile hydrophone between May and October 2004. Spawning aggregations of *C. nebulosus* were detected and recorded at 135 sites, whereas spawning aggregations of *C. arenarius* were detected at 337 sites. Mapping of both species' spawning aggregations shows each species used different areas of the bay to spawn. Over half (57%) of *C. nebulosus* aggregation sounds were detected in lower Tampa Bay, with the remaining 42% split between the upper and middle bay zones. Only one aggregation of *C. nebulosus* (<1%) was located in Hillsborough Bay. *C. arenarius* aggregations were more uniformly distributed within the bay with 33% of the aggregations located in the lower bay, 35% in the middle bay, 20% in the upper bay, and 11% in Hillsborough Bay. *C. arenarius* aggregations were located primarily over sand bottoms, in deeper water towards the middle of the bay. The majority of *C. nebulosus* aggregations were located on or adjacent to nearshore sea grass beds with an average depth of 2.6m. Although *C. nebulosus* and *C. arenarius* are congeners sharing the same spawning season in the same estuary, they use different habitats within the estuary to spawn.

STOYE ECOLOGY & ETHOLOGY

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Turtles versus ducks: Effects of a wetlands drawdown on the population structure of aquatic turtles.

Manipulations of water levels in wetlands are commonly practiced by land managers, but their effects on reptiles and amphibians are studied only rarely. Starting in 2003, we examined the effects of such a drawdown (the draining of an impoundment), on the painted turtle, *Chrysemys picta*, at the Patuxent National Wildlife Refuge in Laurel, Maryland. We used hoops traps, a drift fence, and hand captures to monitor the turtle population before, during, and for two years after the drawdown event, which occurred in July 2003. A total of 1588 painted turtles were collected from six impoundments, of which 375 painted turtles were collected from the drawdown site. There was minimal change in the sex ratio as the pond recovered from the drawdown, from 73% males pre-drawdown to 76% males post-drawdown. The surrounding impoundments were also biased

towards males before and after the drawdown. The population was skewed towards larger females and smaller males after the drawdown but the changes were not significant. We also found little change in species composition; painted turtles comprised 72% of the turtles at the drawdown site before July 2003, compared with 76% following the drawdown. Our results suggest that water level manipulations at this site had only minor impacts on both the population and community structure, at least in the short term. However, our study pond was part of a large wetlands complex that provided refugia for emigrating turtles, thus minimizing the potential harmful effects of the drawdown.

***WARKENTIN, KAREN M.; CALDWELL, MICHAEL S.; WRIGHT, KRISTEN C.; MCDANIEL, J. GREGORY**

(KMW, MSC, KCW) *Biology Dept., Boston University, 5 Cummington St., Boston, MA 02215, USA; (JGM) Dept. of Aerospace and Mechanical Engineering, Boston University, 110 Cummington St., Boston, MA 02215, USA*

Wasp-induced hatching of red-eyed treefrogs: are vibrational cues sufficient?

The arboreal eggs of red-eyed treefrogs, *Agalychnis callidryas*, are preyed on by both snakes and wasps. Embryos in attacked egg clutches often escape by hatching rapidly and up to 30% early. Observations of induced hatching indicate that physical disturbance of the clutch is critical to the anti-predator response, and in playback experiments vibrational cues from snakes are sufficient to induce hatching. We recorded vibrations during wasp attacks and used playback experiments to test their efficacy in inducing hatching. Wasp vibrations are low amplitude, but overlap snake vibrations in frequency and elements of temporal pattern. Playbacks of recorded wasp vibrations elicited essentially no hatching, similar to benign vibration controls (rain recordings). We used synthetic white noise playbacks to assess the amplitude threshold for the hatching response. Wasp vibrations fall below this threshold. The fact that embryos hatch in response to real wasp attacks, but not in response to wasp vibration playbacks, suggests that they use cues other than or in addition to solely vibrations to detect wasps. To assess the spatial spread of such cues in natural wasp attacks, we offered partially protected egg clutches to wasps and recorded the hatching of eggs exposed to direct attack, protected eggs adjacent to exposed eggs, and more distant protected eggs. Hatching was highest in exposed eggs, intermediate in adjacent eggs and low in distant eggs. Thus direct contact with wasps is not required to induce hatching but the cue is spatially restricted compared to snake attacks, in which hatching is widespread. We hypothesize that pressure or tactile cues from embryos squirming and hatching in response to direct attack may cue neighboring eggs to hatch.

WARNER, DANIEL A.

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The adaptive significance of temperature-dependent sex determination in a short-lived lizard (*Amphibolurus muricatus*; Agamidae)

Why is the sex of many reptiles determined by the temperatures that these

animals experience during embryogenesis, rather than by their genes? The Charnov-Bull model suggests that TSD (temperature-dependent sex determination) can enhance maternal fitness relative to GSD (genetic sex determination) if offspring traits affect fitness differently for sons vs daughters, and nest temperatures either determine or predict those offspring traits. Although potential pathways for such effects have attracted much speculation, empirical tests largely have been precluded by logistical constraints (i.e., long lifespans and late maturation of most TSD reptiles). I experimentally tested four "differential fitness" models within the Charnov-Bull framework, using a short-lived, early-maturing Australian lizard (*Amphibolurus muricatus*) with TSD. Eggs from wild-caught females were incubated at a range of thermal regimes, and the resultant hatchlings raised in large outdoor enclosures. I applied an aromatase inhibitor to half the eggs to over-ride thermal effects on sex determination, thus de-confounding sex and incubation temperature. Based on relationships between incubation temperatures, hatching dates, morphology, growth and survival of hatchlings in their first season, we rejected three of the four "differential fitness" models. The model that I accepted states that TSD enhances offspring fitness by generating seasonal shifts in offspring sex ratio: that is, TSD allows overproduction of daughters (the sex likely to benefit most from early hatching) early in the nesting season. In keeping with this model, incubation temperature had a substantial effect on the timing of hatching, and hatching early in the season massively enhanced body size at the beginning of the first reproductive season, albeit with a significant decline in probability of survival. Thus, the timing of hatching is likely to influence reproductive success in this short-lived, early maturing species; and this effect may well differ between the sexes. **STOYE ECOLOGY & ETHOLOGY**

***WARREN, MATTHEW J.; KIZIRIAN, DAVID; DONNELLY, MAUREEN A.**

(MJW) Florida International University, Dept. of Environmental Studies, Miami, FL 33199, USA: (DK, MAD) Florida International University, Dept. of Biological Sciences, Miami, FL 33199, USA

A new species of *Gonatodes* from Guyana (Squamata: Gekkonidae)

A new species of *Gonatodes* is described from the Iwokrama Forest in central Guyana. The new species can be distinguished from all other species of *Gonatodes* by having: bluish-white markings on the top of the head of males, bluish-white stripes on the throat of females, subcaudal scale pattern consisting of an enlarged ventral subcaudal in contact posterolaterally with two scales, followed by a slightly smaller subcaudal in contact posterolaterally with one scale, and four lateral rows of scales on the distal portions of digits. All specimens of the new species were found on boulders along streams. The new species will be compared with others in the genus.

***WASKO, DENNIS K.; SASA, MAHMOOD**

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Spatial ecology of the Fer-de-Lance (*Bothrops asper*) in Costa Rica

The fer-de-lance (*Bothrops asper*) is a large pitviper that ranges from southern Mexico to the Pacific slopes of Ecuador. Although they are an abundant and somewhat notorious member of many tropical communities, very little data exist regarding the species' natural history. Our present study concerns the spatial ecology of *B. asper* in lowland rainforests of Costa Rica. We initiated a radiotelemetric study of *B. asper* in November 2004, at La Selva Biological Station, Heredia Province. At present, a total of 6 males and 7 females have been implanted with radio transmitters. We locate snakes daily when possible (alternating day and night), with a minimum of four locations per week. Data collection was temporarily suspended from 26 January through 24 February, due to equipment failure. At each snake location, we determine GPS coordinates and record several microhabitat variables as well as snake behavior. Here, we report our initial findings in terms of daily and long-term movement patterns, home range size, and microhabitat selection, and discuss direction for further studies.

***WASSERSUG, RICHARD J.; ROBERTS, L.; GIMIAN, J.; HUGHES, E.; SAUNDERS, R.; DEVISON, D.; WOODBURY, J.; O'REILLY, JAMES C.**

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The behavioral responses of amphibians and reptiles in microgravity

Although few vertebrates have been observed in microgravity (<0.01G), certain behaviors are common. Most tetrapods (e.g., rodents, rabbits, cats, turtles, aquatic frogs) interpret weightlessness as if they are upside down and execute repetitive righting responses. However, some unusual behaviors have been observed in the past, including an aggressive display by a rat snake (*Elaphe quadrivirgata*) towards its own body, immobility in a caecilian (*Typhlonectes* sp.), and a skydiving posture in a tree frog (e.g., *Rhacophorus schlegelii*). We exposed 53 individuals from 23 species of amphibians and reptiles to microgravity on an aircraft that flew a parabolic path. The goal was to characterize their behavioral reactions to abrupt exposure to micro-G. Each animal experienced four parabolas, each of 20s micro-G duration. Fossorial caecilians (e.g., *Ichthyophis kohtaoensis* and *Dermophis mexicanus*) and amphisbaenians (e.g., *Geocalamus acutus* and *Leposternon microcephalum*) showed relatively limited movement in micro-G. Limbed quadrupedal reptiles that were non-arboreal (e.g., *Leiocephalus personatus*, *Leiocephalus shreibersi*, and *Scincella lateralis*) showed typical repetitive righting responses with enormous amounts of body motion and tail rotation. We interpreted these violent limb movements as futile attempts to grasp the substrate, and the tail rotations as characteristic of righting responses. In contrast, both arboreal (e.g., *Uroplatus henkeli*) and non-arboreal (e.g., *Palmatogecko rangei*) geckos showed skydiving postures. Terrestrial snakes (e.g., *Thamnophis sauritus* and *Elaphe obsoleta*) initially acted like the limbed terrestrial lizards in

microgravity; they twisted violently. However, some individuals became quiescent when they managed to coil upon their own tails. This suggests that thigmotactic input can mute the vestibulomotor defense that these reptiles reflexively show in freefall. More genera of amphibians and reptiles have now been observed in micro-G than any other vertebrate class. The behaviors of these organisms in micro-G can be understood in light of their normal ecology and taxonomic relationships.

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Pretty in profile: Tadpole responses to mirrors

Tadpoles can alter their behavior, morphology and developmental rate in response to changes in their habitat. Chemical signals from conspecifics and/or predators are the best known stimuli for such plastic phenotypic responses. But what about other sensory modalities and stimuli? Recently it has been shown that tadpoles of several European species prefer to view themselves with their left eye in mirrors. This suggests that anuran larvae recognize and react to the visual image of conspecifics. That observation led us to explore the effect of visual information on the phenotypic responses of anuran larvae. In this study we raised tadpoles of *Rana sylvatica* and *Bufo americanus* in aquaria with no or partially (either 25% or 50%) mirrored walls. We compared their responses to the mirrors with those of tadpoles raised without mirrors, but at two different densities. For *Rana* tadpoles increased density, simulated with mirrors, decreased tadpole growth and developmental rates and increased their locomotor activity the same way that actually increasing their density did. *Bufo* tadpoles did not significantly alter their growth and development in response to either being raised at slightly higher density or with mirrored walls on their aquaria. Our data show that images of conspecifics can be used as visual cues by tadpole in habitat assessment and that those images induce phenotypically plastic changes in several traits. The response of tadpoles to visual cues is taxon-specific. Tadpoles of a *Bufo* species that normally lives at very high density were less responsive to mirrors than those of a *Rana* species that normally lives at lower density. Although researchers studying other *Rana* and *Bufo* species have reported that tadpoles prefer to view themselves in mirrors with their left eye, no such eye preference was found in our study.

***WATKINS-COLWELL, GREGORY J.; GRUNER, HANK**

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The Connecticut amphibian monitoring project

During the period 1970-2000, Connecticut experienced a moderate growth in population (12%) with a significant growth in the amount of developed land

(>100%). Pressure from land use and habitat loss is suspected of contributing to declines in at least some of the 22 native species of amphibian. The Connecticut Amphibian Monitoring Project (CAMP) began in 1998 and is a 15-year, volunteer-based study to assess amphibian communities at both the wetland and landscape scale within 13 randomly selected 3.9 square kilometer blocks representative of Connecticut's changing landscape. Volunteers utilize multiple, standardized methods to survey amphibian populations. Survey data are integrated with a GIS analysis of land use/cover to analyze for differences in amphibian community composition among individual wetlands and among landscapes at the block scale. 2005 represents the eighth year of the project. This presentation will provide a general overview of the project and address the success of various survey methods used by volunteers.

***WATLING, JAMES I.; DONNELLY, MAUREEN A.**

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Nested species subsets of amphibians and reptiles on forest islands in Bolivia

Here we describe nested subset patterns of amphibians and reptiles sampled on 24 forest islands in northeastern Bolivia. Nestedness occurs when species distributions are hierarchical such that species-poor patches comprise a subset of the community on more species-rich patches. Of the four causal mechanisms hypothesized to drive nested subset patterns (differential extinction, differential colonization, passive sampling, and nested habitats), differential extinctions and colonizations have received the most attention, reflecting the importance of area and isolation in fragmented landscapes. Species-based insular distribution functions (IDF's) allow for visual and statistical interpretation of patch presences and absences simultaneously as a function of patch area and isolation. Here we combine an analysis of nestedness in our system with IDF's in order to more fully understand one aspect of community assembly on forest islands. In our system, nestedness was found to be correlated with island isolation (distance from continuous forest), but not island area. We used IDF graphs to infer occupancy of islands by species based on known occupancy as a function of island area and isolation. Based on the inferred data set, we used curve-fitting models to describe colonization thresholds for individual species. We identify four species, the frogs *Bufo margaritifer*, *Chiasmocleis albopunctata*, *Physalaemus* cf *albonotatus*, and the snake *Echinanthera* sp as poor colonizers. When these poor colonizers were removed from nestedness analyses, the correlation between nestedness and island isolation disappeared. We suggest that a combination of small body size and physiological stress limit the ability of these species to utilize the matrix surrounding islands and therefore their ability to maintain populations on far islands. **SSAR SEIBERT ECOLOGY**

***WEAVER, ROBERT E.; BAUER, BLAKE A.**

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Diet and foraging behavior of the Wandering Garter Snake (*Thamnophis elegans vagrans*) at Umtanum Creek, Kittitas County Washington

From June through August 2004 we investigated the diet and foraging behavior of the Wandering Garter Snake (*Thamnophis elegans vagrans*) at a site in southern Kittitas County, Washington. A total of 224 snakes were collected along a 1 km stretch of the creek. More than 50% of snakes contained prey items. Neonate and juvenile snakes were sit and wait predators and fed primarily on cyprinid fish and occasional slugs. Sub-adult snakes were sit and wait and active foragers, and fed on a variety of prey item (fish, slugs and crayfish). Large females were active foragers and fed exclusively on crayfish.

***WEBB, JACQUELINE F.; HERMAN, J. LUKAS; KETTEN, DARLENE R.; CASPER, B.M.; MANN, D.A.**

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The ear and auditory capabilities of butterflyfishes with a laterophysic connection (Family Chaetodontidae)

Butterflyfishes of the genus *Chaetodon* (Family Chaetodontidae) have a swim bladder-lateral line connection (the laterophysic connection), which is thought to enhance the reception of acoustic stimuli by converting pressure oscillations in the swim bladder into fluid flow in the lateral line system. Proximity of anterior swim bladder extensions to not only the lateral line canals of the head, but to the inner ear, has suggested that the ears of these fishes (which make sounds in social interactions) may have enhanced sensitivity to sound. SEM and CT imaging with 3-D reconstruction were used to determine if the ears of *Chaetodon* have the specialized features of the ears of fishes with otophysic connections, thus providing morphological evidence for enhanced auditory capabilities in these fishes. Analysis of the shape of the sensory maculae and associated otoliths, hair cell orientation pattern, and hair cell morphology and density in three species of *Chaetodon* and an outgroup (*Forcipiger*) revealed unremarkable morphology, similar to that found in percomorphs described as hearing non-specialists. ABR (auditory brainstem response) indicates a best frequency of 100-200 Hz in *C. ocellatus*, with an audiogram pattern similar to that of hearing non-specialists. These results suggest that the evolution of the laterophysic connection in *Chaetodon* was not accompanied by specialization of the auditory system or enhancement of sensitivity or frequency range. These results refocus our attention on the evolution of the laterophysic connection as a mechanism for enhancing reception of behaviorally-important acoustic stimuli by the lateral line system in noisy coral reef environments. Supported by NSF grant IBN-0132607 to JFW.

***WEISROCK, DAVID W.; SHAFFER, H. BRADLEY; STORZ, BRIAN L.; STORZ, SHONNA R.; VOSS, S. RANDAL**

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Multiple EST loci provide perspective on mtDNA polyphyly for a paedomorphic salamander species

Single gene-tree estimates of phylogeny and species boundaries can be hampered by factors such as the retention of ancestral polymorphism and introgressive gene flow and these problems may be exacerbated in species radiations where lineage sorting and sexual isolation are often incomplete. In this study we present a multilocus phylogeographic assessment of *Ambystoma ordinarium*, a paedomorphic salamander species within an adaptive radiation of North American tiger salamanders (the *Ambystoma tigrinum* complex). Previous mitochondrial DNA (mtDNA) studies suggested that *A. ordinarium* comprises two genetically differentiated lineages with polyphyletic origins. Using expanded sampling within *A. ordinarium* and representatives of tiger salamander lineages, gene trees were constructed from mtDNA and eight expressed sequence tag (EST)-based nuclear loci. The expanded mtDNA tree revealed an even greater extent of polyphyly for *A. ordinarium* than previously uncovered. In contrast, seven of eight nuclear loci reveal patterns of monophyly or paraphyly for *A. ordinarium*. We conclude that *A. ordinarium* has a single evolutionary origin and that mtDNA polyphyly is likely the product of ancestral polymorphism retention and/or mitochondrial introgression with additional tiger salamander species. This latter hypothesis is supported by the fact that western *A. ordinarium* localities contain mtDNA haplotypes that are identical or minimally diverged from mtDNA haplotypes sampled from a nearby paedomorphic species, *A. dumerilii*. Bayesian analysis of population genetic structure within *A. ordinarium* strongly support its subdivision into eastern and western population-level units and suggest that the *A. tigrinum* complex harbors greater species diversity than what is already recognized based on ecological and morphological differentiation. This study demonstrates the importance of using a multilocus genealogical perspective in phylogeographic studies and highlights ESTs as a valuable and tractable source of intraspecific nuclear polymorphism.

***WELSH, STUART; OSIER, LIZ; SHEEHAN, KEN**

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Habitat use of the Elk River Spotted Darter

The spotted darter, *Etheostoma maculatum*, is distributed disjunctly within the Ohio River drainage. Researchers have generalized spotted darter habitat as large rocks and swift riffles. In West Virginia, spotted darters occur only within the middle section of the Elk River system, but information on habitat use is lacking. With direct observation (snorkeling), we examined microhabitat use of spotted darters in glide, riffle, and run habitats at three sites in the Elk River. Contrary to habitat use data from other populations, spotted darters in the Elk River were observed primarily near large rocks and within moderate velocities in glide habitats (transitional habitats between tails of pools and heads of riffles). The Elk River spotted darter, a habitat specialist, is highly vulnerable to habitat alterations, such as sedimentation and substrate embeddedness. Given a small geographic range, further ecological studies are needed for conservation and management of Elk River spotted darters.

WESTNEAT, MARK W.

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Labroid phylogeny and the search for perciform relatives using outgroup jackknifing

Phylogenetic relationships among the labroid fishes (cichlids, damselfishes, surfperches and wrasses) have been the subject of intensive research by morphologists for many years. A primary focus of this research has been the pharyngeal region, which yields a number of characters suggesting their close relationship. Recently, molecular data have questioned this close alliance, suggesting that cichlids, pomacentrids, and embiotocids are closely related but that labrids are rooted to a different part of the perciform tree. Neither morphology nor DNA has yet provided a clear answer to the question of what other perciform fish families might be close relatives to labroid families. Key questions remain: Are labroids one clade or more? What non-labroid families are close relatives to these families? In this context, we assembled a dataset consisting of DNA sequences from mitochondrial and nuclear genes from over 120 perciform taxa including all major labroid clades to test hypotheses of labroid relationships. Six genes and about 4KB were analyzed using outgroup jackknifing, in which alternative sets of outgroups were used to assess support for labroid clades. The molecular evidence strongly supports the sister-pair of embiotocids and pomacentrids, with cichlids a close relative but often with other families inserted. The labrids are more closely allied with more basal percoid lineages, with the Gerreidae a possible sister-group to the Labridae. Phylogenetic hypotheses splitting labroid fishes into two or more clades do not require many extra steps when considering morphological character data, but do require reinterpretation of both structural and functional hypotheses of pharyngeal jaw evolution in fishes.

***WHITE, MATTHEW M.; ZIPFEL, KATHERINE**

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Status of native walleye in Rockcastle River, KY and Kanawha River, WV

In recent years, a number of distinct walleye populations have been identified from the southern part of the range. These southern walleye populations include Alabama, Missouri, Kentucky, Virginia, and the Ohio River. Despite the widespread use of introduced walleye from Lake Erie origin, some of these native populations appear to have maintained their genetic integrity while others appear to have introgressed with introduced stocks. This project was designed to evaluate the genetic integrity of the native walleye population in Rockcastle River, KY. Mitochondrial DNA PCR-RFLP analysis and microsatellite DNA variation suggest that the Rockcastle River walleye remains genetically pure despite widespread stocking of Lake Erie-derived fish in a downstream impoundment (Lake Cumberland). We also evaluated the distribution of native populations in West Virginia using mitochondrial DNA PCR-RFLP. Our data suggest that the native walleye are widely distributed but only locally common in West Virginia streams. The RFLP analysis used in these studies also identifies the Ohio River and New River walleyes, suggesting that these southern walleye populations may form a monophyletic group distinct from northern walleyes.

***WHITE, SCOTT, E; SECOR, STEPHEN M.**

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Cardiac output and patterns of blood flow for the Burmese python

In considering the tremendous metabolic response exhibited by pythons during meal digestion and the well-known phenomenon of blood shunting to active tissues, we measured blood flow through the carotid artery, dorsal aorta, superior mesenteric artery and hepatic portal vein of Burmese pythons (*Python molurus*) while fasting, exercising, and digesting. Pythons (0.1 - 14 kg) were surgically implanted with perivascular blood flow probes and measurements were made of snakes at rest, crawling, and during the digestion of rodent meals equaling in mass to 5 to 55% of snake body mass. We found exercise to generated a 2.3-fold increases in heart rate and a 2.8-fold increase in cardiac output (summed flow through carotid arteries and dorsal aorta), while reducing blood flow to the small intestine by 65%. During the digestion of meals equaling 25% of body mass, pythons experienced respective 2.5, 5, 11, and 18-fold increases in heart rate, cardiac output, superior mesenteric arterial flow, and hepatic portal flow. In response to both exercise and digestion, cardiac output does not change, but superior mesenteric flow is reduced by 85%. While python heart mass scales with body mass with a mass exponent of 0.78, cardiac output during rest, exercise, and digestion was found to scale with exponents between 0.70 and 0.72. By increasing digestive demand with larger meals, pythons respond by further elevating cardiac performance, increasing cardiac output by 10-fold during the digestion of meals equaling 55% of body mass. Pythons in exhibiting the largest

known postprandial increase in cardiac output and blood flow to the digestive system, demonstrate the impressive functional capacity of their cardiovascular system.

***WHITENACK, LISA B.; MOTTA, PHILIP J.**

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Performance of shark teeth during puncture: implications for the mechanics of cutting

Feeding performance plays an important role in overall fitness. Tooth morphology contributes to feeding performance; however this component has largely been ignored in functional morphological studies of elasmobranch feeding. The goal of this study is to explore the evolution of selachian teeth in a biomechanical and functional context. Here we report the results of preliminary testing of teeth during puncture for nine species of carcharhinid and three species of lamnid sharks. Teeth were driven into prey items at a rate of 400 mm/s using a MTS MiniBionix II universal testing system and force and pressure at initial penetration, maximum force, and work to fracture were analyzed. Results indicate that during unidirectional puncture, teeth with a wider triangular cusp produce more force and pressure than a tooth with a narrow cusp. Narrow anterior teeth of *Isurus oxyrinchus* required an average of 15.03 N of maximum penetration force, while the largest average maximum penetration force (40.35 N) was for an upper anterior tooth of *Carcharhinus leucas*, occurring after the cross sectional area of the tooth abruptly increases proximal to the distal notch. Results also indicate that serrations play a role in the overall dynamics of performance due to binding of material between individual serrations. As the tooth moves through the material, binding occurs as tooth serrations increase in size towards the base, causing high stresses on the tooth and prey. As the shark engages in head shaking, fibers are broken causing a decrease in stress on the tooth. Notching, seen in the teeth of *C. leucas* and *Galeocerdo cuvier*, can be thought of as an extreme serration, providing more tensile stress to the fibers during head shaking. These results have implications for studies of fossil chondrichthyans, where typically tooth morphology is used to predict feeding ecology in the absence of performance data.

***WHITFIELD, STEVEN M.; DONNELLY, MAUREEN A.**

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Community structure of a Costa Rican leaf-litter herpetofauna: prey use and seasonal activity

To clarify patterns of trophic and temporal resource utilization and elucidate the presence and nature of community structure, we studied a sample of leaf-litter frogs and lizards systematically collected over a 13-month period from a lowland wet forest in Costa Rica. We examined 6324 individual prey items taken from the stomachs of 940 individuals representing 16 species. We used data on patterns of monthly abundance from 1996 individuals from an entire seasonal cycle to

explore temporal partitioning in seasonal activity. Species utilize prey differently with respect to both size and type. Members of this assemblage belong to two distinct trophic guilds, a generalist guild comprised of most lizards and frogs, and an ant-specialist guild composed of three species of frogs. Null models indicated that prey use is not random, niche breadth and guild structure are important, and prey use by generalists is hyperdispersed. Patterns in seasonal activity were either random or hyperdispersed. Prey use is more likely influenced by deep phylogeny than interspecific interactions, and seasonal activity is probably driven by physiological constraints or reproductive phenology than interspecific interactions. Frogs and lizards show great similarities in diet and seasonal activity patterns, suggesting that interactions between these two groups are important and that studies that examine only a portion of this assemblage may overlook important community dynamics. **SSAR SEIBERT ECOLOGY**

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Swimming depth of the Dolphinfish (*Coryphaena hippurus*) from active and passive telemetry

Seven Dolphinfish (*Coryphaena hippurus*) were tagged with Vemco V16P (pressure-sensitive) transmitters and tracked continuously from a vessel for periods ranging from 1.3 to 40.1 hrs, with a average track duration of 16.3 hrs. Four additional fish were tagged with V16P R-coded transmitters and subsequently monitored for several days by Vemco VR2 receivers that were stationed on Fish Aggregation Devices (FADs). When unassociated with FADs, dolphinfish swam within the upper 75-100m of the water column during the day, showing more variable depths and deeper dives (between 30 and 160m) during the night. When associated with a FAD or other drifting debris, fish stayed much shallower (often within the upper 10m) and tended to make deeper excursions during the day instead of at night. Water temperature data from expendable bathythermographs deployed during four of the active tracks showed that fish stayed within the mixed layer during the day, with their deepest dives often being limited by the depth of the thermocline. At night, unassociated fish dove into cooler water but still limited their depths to the isotherm 3°C cooler than the mixed layer temperature, regardless of dive depth.

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A comparative analysis of mouthbrooding styles in cichlid fishes

A mouthbrooding cichlid carries its eggs in its mouth. Mouthbrooding is one of the most enigmatic forms of parental care. It is costly to a parent - a mouthbrooder typically cannot eat during mouthbrooding - yet beneficial to the fry - mouthbrooder fry are often much better developed at independence than are other fish fry. There is great variation in the form and extent of mouthbrooding, yet little is known of the life-history of cichlids exhibiting this behavior. Barlow recently devised a classification scheme for mouthbrooders based on key aspects of their behavior, i.e., the timing when the eggs are picked up, which individual(s) brood the eggs/fry, and how the fry are released. To apply this classification to cichlids, I examined the primary, secondary, and hobbyist literature available on mouthbrooding. I recorded information on: genus/species location; timing of egg pick-up; which parent holds eggs; parent size during brooding; if the fry are subsequently ceded to another individual; if fry are allowed to re-enter the parent's mouth after being released; what stage/size fry are upon release; average egg size; and number of fry per brood.

STORER ICHTHYOLOGY

***WIDRIG, AMANDA L; WOJAKOWSKI, MARIA; BURKE, RUSSELL L.**

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The impact of microhabitat on nest temperatures and offspring sex ratios in diamondback terrapins

Diamondback terrapins (*Malaclemys terrapin*) are estuarine turtles that exhibit nest site selection in the field and temperature-dependent sex determination (TSD) under constant incubation temperatures in laboratory studies. Our goal was to investigate whether microhabitat variables, potentially used as cues by nesting females, influence nest temperatures and offspring sex ratios. Relationships among microhabitat variables, nest temperatures, and sex ratios were analyzed for 80 terrapin nests in Jamaica Bay Wildlife Refuge in New York City. Analyses were performed using the middle third period of incubation, the thermosensitive period, during which hatchling sex is determined. We found that microhabitat factors influence nest temperature and subsequently offspring sex ratio. Total overhead plant cover, % bare ground, % litter, and % monocot plant cover were significantly associated with mean nest temperature, but % dicot plant cover was not. Average nest temperature and critical temperature units were both significantly associated with offspring sex ratio. These results show that nest site selection can be an important factor in offspring sex ratio in terrapins.

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Effects of temperature and light on background color matching in
Mediterranean geckos (*Hemidactylus turcicus*)

The ability to change skin color is a relatively common phenomenon in lizards and its occurrence is often related to camouflage. Our field observations have suggested that Mediterranean geckos (an often ubiquitous introduced species in many metropolitan areas of the southern United States) have the ability to lighten and darken in response to the color of their background. On light backgrounds, the geckos were typically light pink whereas on dark backgrounds they were typically much darker with a brownish hue to their skin. To assess the ability to background match in this species, we investigated the main effects of temperature (20, 25, and 30C), illumination (total darkness and dim lighting), and their interactions on the lizard's ability to match their skin darkness to four levels of background color (black, gray, white, and a combination of the three). Each lizard was measured in a repeated-measures design. While temperature had little effect, illumination strongly influenced the lizard's ability to background color match. In the absence of light, 73% of the lizards were light in color. This suggests that lighter skin pigmentation in the dark may be the "default" setting with the melanocytes contracted. In dim lighting, the lizard's skin darkness closely matched the background darkness in most cases (81%). These nocturnal lizards are typically associated with human development where low levels of illumination are often present at night. The ability of Mediterranean geckos to accurately color match under the conditions of human habitation may have contributed to their success as a colonizing species.

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A temporal comparison of anuran biodiversity in the Peruvian Amazon

An anuran survey of Reserva Amazonica, Peru was performed and compared to four previous field seasons. The first surveys were conducted 16 years previous as part of BIOTROP (Neotropical Biological Diversity Program) begun in 1989. During 26 December 2004 to 16 January 2005 eleven researchers surveyed anurans following the BIOTROP protocol, systematically sampling systems of trails and quadrats of two study zones. A total of 415 observations were recorded representing a total of 39 species. In comparison, the original 1989-1990 field season yielded 25 amphibian species with three researchers totalling 178 observations. Four researchers during the 2000-2001 field season recorded 119 observations, totalling 32 species. Likewise, six surveyors recorded 32 species during the 2002-2003 field season. Two of the 39 species, *Osteocephalus planiceps* and *Phyllomedusa bicolor*, observed during the most recent field season were not previously recorded at Reserva Amazonica. Comparisons between field seasons are limited by a number of confounding factors including weather, sampling bias and other stochastic effects. Nonetheless, this research represents a unique opportunity to study the long-term changes in Amazonian anuran diversity.

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Progress and prospects for integrative research on the tree of life of fishes

The past forty years have seen much progress in elucidating the tree of life of gnathostome vertebrates of the piscine persuasion. Much of this fundamental work has been pursued with morphology and the application of the principles of phylogenetic systematics. Easy access in obtaining molecular data has opened up new sources of character information. The question is: how can communities of systematists working on diverse data sources join in collaborative research to further our understanding of the phylogeny of fishes? Several models for integrating diverse research programs have emerged and will be discussed.

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Elasmobranchs of Everglades National Park

Few directed studies have been conducted on the elasmobranch fauna of Everglades National Park, so little is known of their importance in this area. Data on elasmobranchs captured during surveys for smalltooth sawfish in Everglades National Park were used to examine species occurrence, distribution and movement patterns. Surveys were conducted utilizing bottom set longlines, gillnets, seine nets and rod and reel from July 2000 to February 2005. A total of 1015 elasmobranchs of 12 species were identified within the Park (*Carcharhinus acronotus*, *C. isodon*, *C. leucas*, *C. limbatus*, *Dasyatis* spp., *Galeocerdo cuvier*, *Ginglymostoma cirratum*, *Negaprion brevirostris*, *Pristis pectinata*, *Rhizoprionodon terraenovae*, *Sphyrna mokarran* and *S. tiburo*). *Carcharhinus leucas* (n=302), *N. brevirostris* (n=239), *C. limbatus* (n=126) and *G. cirratum* (n=112) were encountered most frequently. Data from Mote Marine Laboratory's tag/recapture database showed that 20 *C. leucas*, three *C. limbatus*, eight *G. cirratum*, 16 *N. brevirostris* and two *S. tiburo* were tagged and/or recaptured within the park after periods at liberty of 1 to 1099 d. All 16 *N. brevirostris* were tagged and recaptured within the boundaries of the park (44 to 1061 d at liberty). *Carcharhinus leucas*, *C. limbatus* and *G. cirratum* were tagged or recaptured as far north as Tampa Bay on Florida's west coast. No recaptures were reported from Florida's east coast or south of the park boundary. The salinity, temperature, depth and dissolved oxygen data were analyzed to determine any environmental preferences. The distribution, seasonal occurrence and size/frequency distribution of common shark species will be presented.

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Mechanics of suction generation during feeding in bamboo sharks

Although recent studies have increased our understanding of suction generation during feeding in teleosts, similar studies on elasmobranchs are lacking. The kinematics of selected internal head and branchial structures in bamboo sharks, *Chiloscyllium plagiosum*, are measured using sonomicrometry to quantify elements that are directly responsible for internal expansion of the orobranchial cavity, and therefore the generation of suction inflow. Simultaneous pressure recordings inside the orobranchial cavity were used to assess pressure flow at strategically important locations during feeding. A compressive preparatory phase occurs prior to the expansive phase in half of the capture events. An anterior to posterior progression of expansion occurs in the gape, hyoid, and pharyngeal cavities during suction feeding. Pressure in the gape and hyoid regions decrease rapidly as the mouth opens and peak subambient pressures are reached at approximately the same time as peak gape. Peak subambient pharyngeal pressure is less extreme and occurs prior to that in the buccal and hyoid cavities. Hyoid depression appears to be a dominant feature of generating suction in sharks. A major advantage of sonomicrometry is continuous quantification of moving structures that are not visible externally or have moved out of camera view. Sonomicrometry reveals that interhyal distance decreases and the hyoid arch is drawn anteriorly during feeding. In contrast to preliminary evidence using videography that shows the onset of upper jaw protrusion following peak gape, sonomicrometry reveals that upper jaw protrusion actually begins much earlier, shortly after the onset of lower jaw depression.

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Sexually dimorphic skate snouts

Although sexual dimorphisms in head shape are well documented among teleosts, only a single example of sexually dimorphic head shape is documented in elasmobranch fishes. The rostral cartilages of male bonnethead sharks, *Sphyrna tiburo*, elongate concomitantly with the clasper cartilages at sexual maturity creating a distinct bulge along the anterior margin of the cephalofoil. To determine if this phenomenon is unique to *S. tiburo* or widespread among the elasmobranchs, we examined rostral cartilage length and head shape among deep water and coastal skate species (Rajidae) from both the Atlantic and Pacific basins. We sampled individuals of both sexes across a range of sizes. We photographed the dorso-ventrally compressed skates using backlighting to facilitate visualization of the rostral cartilages thus precluding the need to x-ray the heads. Twelve homologous landmarks on the head were digitized and a

Procrustes analysis was employed to create a consensus model for each species. A principal components analysis was used to quantify departure of the individuals from the consensus model and test for differences between the sexes. For the little skate, *Leucoraja erinacea*, we found that head shape among juveniles did not differ significantly between the sexes, whereas adults exhibited highly significant differences. In addition, significant ontogenetic changes in head shape were apparent for both sexes. Rostral cartilage length was significantly greater for females than males; a reversal of the pattern seen in *S. tiburo*. In contrast, rostral cartilage length did not differ significantly between the sexes in the California ray, *Raja inornata*. Thus, sexually dimorphic head shape may be widespread within the class Chondrichthyes and close examination of the rostral cartilages of other elasmobranch species may reveal previously overlooked differences.

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Otolith structure and the age and growth of juvenile White Seabass
(*Atractoscion nobilis*)

Since 1995, the Nearshore Marine Fish Research Program (NMFRP) at CSUN has been under contract with the California Department of Fish and Game and the Ocean Resources Enhancement and Hatchery Program to sample and determine the spatial and size distributions, seasonality, and abundance of white seabass (*Atractoscion nobilis*) in the shallow, nearshore waters of Southern California. Currently, age estimations are made using the total length of each fish, based on previous studies of the species. Although the age estimations of individuals that have a total length in the middle of each estimated age class range are more than likely correct, the age of individuals toward the ends of each range are questionable. The sagittal otoliths of every white seabass caught in the last ten years (with the exception of those released by OREHP hatcheries) have been extracted and labeled. A random sample of one hundred otoliths were taken from each sampling year from 1997 to 2004, for a total of 800. Each otolith is transversely sectioned through the focus and viewed under a compound microscope using transmitted light. Opaque growth rings appear brown while translucent rings are relatively clear. Each pair of opaque and translucent rings is thought to represent a single year of life. While most otoliths have distinct opaque and translucent areas, white seabass otoliths have large, variable intermediate areas between obvious opaque and transparent growth. These areas appear to show subannular growth rings in addition to annuli, and are hypothesized to be lunar growth rings. The lunar ring hypothesis will be verified by determining the number of subannular rings per annulus and daily rings per subannulus. **STORER ICHTHYOLOGY**

***WILLIAMS, ROD N.; GOPURENKO, DAVID; MCCORMICK, CORY R.; DEWOODY, J. ANDREW**

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The breeding biology of the tiger salamander (*Ambystoma tigrinum*) as assessed with molecular genetic markers

Despite decades of research, many aspects of urodele reproduction are poorly known due to their secretive nature. We used molecular markers to conduct genetic parentage analyses on wild tiger salamanders to better understand their breeding biology. In 2002, we collected 41 egg masses from an Indiana wetland alongside a road in a \approx 100m linear transect. DNA was extracted from individual embryos contained in egg masses, and 1051 such embryos were genotyped at four hypervariable microsatellite loci. Those data allowed us to reconstruct the multilocus genotypes of the dam and her mates. By estimating genetic distances among embryos within an egg mass and clustering them in a UPGMA tree, we determined that egg masses were sometimes admixed. In other words, two or more females had oviposited at exactly the same site such that their clutches coagulated into a single jellified egg mass. The clustering and other analyses indicated that the 41 putative egg masses actually consisted of 53 half- or full-sib clutches. Fifteen of the 53 clutches were excluded from analyses because of insufficient sample size (too few embryos), mutations, or null alleles. Of the 38 remaining clutches, 23 (60%) consisted exclusively of full-siblings (i.e., were singly sired) and 15 (40%) were multiply sired (mean 2.3 males/clutch). Parentage could be genetically assigned to the efforts of at least 16 females and 21 different males. The geographic distribution of parental gametes among egg masses was patchy, ranging from 0.30m to as far as 40m along the transect. Our data are the first to address the microspatial distribution of a females eggs during oviposition. We also document for the first time multiple paternity in wild tiger salamanders, although additional studies are needed to quantify individual reproductive success and address various mate choice models.

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Why species do not exist, and why we so desperately want species to exist

Biological concepts change over time as we learn more about the world around us and gain a deeper understanding of how it works. Phylum, order, class, family, genus, and population are no longer considered 'real'. Rather, they are considered semi-arbitrary groupings. However, many still believe species are real and are searching for a species concept(s). It will be argued based on temporal evidence and the plethora of data types (morphological, molecular, behavioral, etc.) that are becoming more and more available that species are also arbitrary groupings. A couple reasons people are loath to abandon the idea of species are: 1) historical inertia from the time of Ancient Greeks and earlier; 2) how the human mind works and its need to categorize and organize concepts. Even if species are not real, it is still necessary for us to place organisms into 'species' in order to communicate ideas. It is important to focus on the processes

that create and maintain diversity, instead of arguing about definitions.

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Phylogenetic inference of the extant crocodylians based on nuclear gene sequences

The extant crocodylians comprise 23 species divided among three major lineages, Alligatoroidea, Crocodyloidea, and Gavialoidea. Genetic analyses of relationships based on biochemical/ molecular markers have consistently supported conclusions of morphological data with the following noteworthy exceptions. While morphologists have typically placed the true gharial, *Gavialis gangeticus*, basal to all other living crocodylians, virtually every molecular study has suggested a closer relationship to the false gharial, *Tomistoma schlegelii*. Recent molecular data suggests that *Crocodylus cataphractus* should be placed outside of the genus *Crocodylus* and should be recognized as a distinct monotypic genus. Mitochondrial DNA evidence suggests that the two sub-species, of *Osteolaemus tetraspis* could warrant distinct specific status. Relationships between *Caiman* and *Melanosuchus* and within the *Caiman crocodilus* complex are poorly resolved and researchers disagree over how many species or subspecies comprise the complex. Currently, we are using several nuclear sequences from multiple individuals of all species of crocodylia to help elucidate these remaining controversies.

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Diversification in the Neotropical cichlid genus *Cichla*

To investigate the influence of historical hydrography and landscape heterogeneity on diversification in Neotropical fishes, we developed a molecular dataset from the cichlid genus *Cichla* and used it to infer the phylogenetic and genealogical relationships among species and populations. The mitochondrial control region and a portion of the cytochrome *b* gene were sequenced for multiple individuals of each of the 5 nominal *Cichla* species and several potential undescribed species (identified by diagnostic color patterns). Phylogenetic analyses indicate the genus *Cichla* represents a more complex diversity than is represented by the 5 named species. A species-level phylogeny suggests that *Cichla intermedia* and *orinocensis* are sister species, and this clade is sister to a clade that contains *C. monoculus* and *ocellaris*. *C. temensis* is a part of a lineage sister to the other four described species. The distribution of those four species members agrees with published patterns of Guayanan shield fish biogeography (e.g. *Potamorhaphis* and *Prochilodus*) emphasizing a closer relationship between

the Amazonas river and drainages of the Guyanas to the exclusion of the Orinoco. However the *temensis*-clade appears to have separated predating the development of that pattern and exhibits a diversification pattern reflecting Amazon drainage hydrography. In addition to the data for the phylogeny, data from the control region for additional individuals throughout the natural range of the genus were also collected, including populations in the Orinoco, Essequibo, Maroni, and Amazonas rivers including the tributaries Juruá, Negro, Madeira, Tapajós, and Xingu. Phylogeographic analyses reveal that *C. orinocensis* shows the greatest relative panmixia species, whereas the other nominal species show haplotype distributions and population relationships which imply isolation of significant duration and complex historical relationships among geographical units. These analyses also suggest that biological characteristics of each species play a significant role in how those species differentiate over the same heterogeneous landscape.

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Post-drought responses of semi-aquatic snakes inhabiting an isolated wetland: Insights on different strategies for persisting in a dynamic habitat

Many habitats are temporally dynamic, prompting the evolution of diverse strategies to persist in the face of fluctuating environmental conditions. Isolated wetlands in the southeastern United States harbor high diversities and abundances of aquatic and semi-aquatic organisms. However, drought may render wetlands temporarily unsuitable for some species, sometimes for years at a time. Ellenton Bay, an isolated 10-ha wetland in the Upper Coastal Plain of South Carolina, has hosted several long-term studies of the responses of semi-aquatic reptiles and amphibians to periodic extreme droughts. We studied the movement patterns and demography of seven species of semi-aquatic snakes at Ellenton Bay following complete drying of the bay during a drought from 2000 to 2003. Snakes adopted multiple strategies to persist during the drought and apparently fared differently as a result: *Agkistrodon piscivorus* migrated to and from the wetland annually, fared well, and reproduced during the drought; *Nerodia fasciata* suffered dramatic population declines and apparently did not reproduce, and *N. floridana* was locally extirpated during the drought; *Seminatrix pygaea* aestivated within the wetland and was less negatively affected by the drought than *Nerodia*. Intraspecific differences in response to drought demonstrate that conservation measures may affect species differently and highlight the importance of terrestrial habitat around wetlands for semi-aquatic reptiles.

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Age class interactions in a marine goby, *Elacatinus prochilos*

Many reef fishes settle monthly throughout the year, so multiple cohorts generally occur together. Yet, much research has focused on a single age class (i.e., settlers) and has ignored age class interactions. The focus of this work was to quantify within and between age class interactions of new settlers and older fish of a marine goby, *Elacatinus prochilos*. All age classes of this species co-occur on live coral substrate. Thus, all age classes experience and interact with all other age classes. In addition, previous work in this system has shown that post-settlement processes varied over space and drove spatial variation in habitat quality (i.e. post-settlement survival of fishes varied among coral heads at a common density of fishes). Therefore, I also explored how variation in habitat quality may modify interactions between age classes. I found that both inter- and intra-cohort interactions were similar (each age class had similar per capita effects on one another and each other). However, there was evidence for older fish being less affected by settlers than settlers were by other settlers. There was also an indication that variation in habitat quality affected the two age classes differently. This work highlights that in order to extrapolate longer term dynamics (i.e., multiple generations) over larger spatial and temporal scales, we must consider how different age classes or stages interact with one another, and, if appropriate, explore reef fish dynamics using a stage structured approach.

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Conservation genetics of the spotted turtle (*Clemmys guttata*) at the western range limit: Management implications

Spotted turtles (*Clemmys guttata*) are a small emydid turtle that inhabit a variety of freshwater habitats; and, range from southern Ontario to northcentral Florida and westward from the Mid-Atlantic to the Great Lakes Region. They are listed in Illinois as endangered and are considered vulnerable under CITES. The range of the spotted turtle in Illinois has been reduced so drastically that only two small isolated populations now exist. This combined with the threat of future population declines have prompted land-managers and natural heritage biologists to incorporate emerging technologies so that adaptive conservation and management strategies can be successfully implemented at a wide range of spatial scales. We used DNA fingerprinting to provide the first analysis of the genetic composition of spotted turtle at the western range limit in northeastern Illinois. Genetic similarity between the two extant Illinois populations is high, but they are both genetically distinct entities. An analysis of population structure revealed a measurable level of genetic divergence between the two populations,

indicating a lack of dispersal and gene flow for a considerable period, possibly as late as the pre-settlement. In addition, a comparison of spotted turtle phylogeny showed a greater genetic difference among other Midwestern and Eastern populations. Preservation of the small Illinois populations must combine demographic and genetic considerations in the context of a metapopulation paradigm. A first step should be to preserve local gene pools while augmenting numbers, with the goal of preventing the extinction of these genetically, ecologically, and evolutionary distinct populations.

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Using turtles to promote a grassroots environmental education program in the Lower Tennessee and Conasauga watersheds

In 2003, The University of Tennessee at Chattanooga, The Tennessee Aquarium, and the Tennessee River Gorge Trust began a collaborative effort to develop a comprehensive environmental program that focuses on native freshwater turtles, entitled The Tennessee River Gorge Turtle Conservation Initiative. One of the major goals was to establish an Environmental Awareness Program that would disseminate information to the public about the diverse ecological research conducted by students and scientists at the Tennessee Aquarium Research Institute, and The University of Tennessee at Chattanooga. Today, the Environmental Awareness Program has established four distinct and regionally recognized programs that cater to all ages and socioeconomic classes. In general, the Environmental Awareness Program is making local citizens aware of the rich and diverse ecosystems that are found throughout the region, and that those citizens have developed the necessary background to make sound environmental decisions. In addition, the program has provided educational information on the regional biodiversity and ecosystems, the conservation of habitats, the scientific method, environmental toxicology, and population and community ecology.

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Behavioral and metabolic responses of southern red-backed salamanders to predatory stimuli: influence of body size

In its natural habitat, visibility often is limited for terrestrial salamanders, so chemoreception may be important for detection of predators. I conducted experiments examining the effect of chemical stimuli from predatory ringneck snakes on the foraging behavior and metabolic rates of *Plethodon serratus*. In both studies, individuals were exposed to substrate cues from ringneck snakes, five-lined skinks (nonpredator control), and dechlorinated water (blank control). In a separate foraging experiment, I examined the response of *P. serratus* to airborne cues from the same stimuli. Foraging activity was measured by the number of

strikes at prey during the 5 minutes following exposure to the stimuli. Metabolic rates were calculated using % oxygen consumed, measured by constant-volume respirometry, before and after exposure to the stimuli. Overall, larger salamanders (SVL > 32 mm) foraged more than smaller salamanders, and salamanders showed reduced foraging activity in the presence of substrate cues from predators, but not in the presence of airborne cues. Metabolic rates of smaller salamanders showed greater changes in the snake treatment compared to the nonpredator controls. Metabolic rates of larger individuals did not differ among treatments. In summary, salamanders reduced foraging activity in the presence of substrate cues from predators, which may reduce their chances of being detected. Results of the experiment involving airborne cues may indicate that the chemical used in the detection of ringneck snakes is nonvolatile. In contrast to the behavioral responses, metabolic responses were dependent on body sizes with only small salamanders discriminating between predatory and nonpredatory stimuli. The lack of discrimination by large salamanders may be because they are less vulnerable to gape-limited predators. Large salamanders also may be reluctant to flee in the face of predation because they are likely to be territory owners and loss of territories might have serious fitness consequences.

SSAR SEIBERT MORPHOLOGY & PHYSIOLOGY

***WINEMILLER, KIRK O.; MONTOYA, JOSE V.; ROELKE, DANIEL L.; LAYMAN, CRAIG A.; COTNER, JAMES B.**

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Seasonally varying impact of detritivorous fishes on benthic resources of a Neotropical floodplain river

The Cinaruco River, a lowland floodplain river in the Venezuelan llanos, has a strongly seasonal hydrology, low nutrient availability, and high fish diversity and abundance. To examine seasonal variation in the magnitude of fish effects on benthic organic matter and algae, we conducted fish enclosure/enclosure experiments in the littoral zone of the river channel and connected lagoons. During the dry season of 2002, large-mesh enclosures in the channel accrued significantly more sediment, organic material, and chlorophyll than control cages. Grazing scars suggested the bocachico, *Semaprochilodus kneri*, was a major consumer of organic-rich sediments. Further experiments were conducted to test the hypothesis that the relative strength of top-down (grazer) control of organic matter in sediments varies according to species, hydrologic period, and habitat. Densities of *S. kneri* and most other fishes are highest during the low-water season. At flooding onset (May), *S. kneri* migrate to the Orinoco River to reproduce and feed, so that their densities are extremely low in the Cinaruco during the interval when nutrient inputs from newly flooded plains should be greatest. Experiments conducted during March 2002 (low water) in the channel and floodplain lakes revealed significant treatment effects (large fish enclosure; total fish enclosure; *S. kneri* enclosure; control) for accumulation of sediment mass, organic material mass, and chlorophyll a on tiles. Chlorophyll a

concentrations were significantly greater in lagoons than river channel sites, a pattern consistent with the view that chlorophyll in sediments is partially derived from phytoplankton, given that water column primary production is higher in lagoons during low water. Mean mass of sediments and organic material matched our prediction of grazer control during the low-water season. Experiments during the early rising-water phase, the period when *S. kneri* cease feeding and emigrate, yielded no significant habitat or treatment effects. Overall, results support a model predicting continuous, gradual change in the magnitude of top-down effects of benthivorous grazing fishes on organic material on sediments as a function of seasonal changes in water level.

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Reproductive costs differ between aquatic and terrestrial habitats:
Reproductive locomotor impairment in a semi-aquatic snake

Cost of reproduction is a central tenet in life history evolution. In most life history models a tradeoff is assumed to exist between reproductive investment and parental survival. Consequently, reproductive investment is thought to be constrained by an increased probability of mortality during pregnancy. Although several studies have documented reproductive costs in terms of reduced locomotor performance, few studies have determined the reproductive costs of pregnancy in aquatic environments. This knowledge gap is important because semi-aquatic reptiles often rely on aquatic locomotion to escape predation during pregnancy and biomechanical models suggest that costs of locomotion may differ between aquatic and terrestrial habitats. In this study, I compared the relative impacts of pregnancy on maximum locomotor performance in aquatic and terrestrial environments for a semi-aquatic snake (*Seminatrix pygaea*). I found that the reproductive cost of pregnancy on maximum velocity was high in water ($P < 0.001$) and on land ($P < 0.001$). However, pregnancy impaired locomotion on land (mean \pm SE; % decrease = 72.8 ± 21.6) significantly more than in water (% decrease = 59.4 ± 12.8 ; $P = 0.049$). Because most life history models predict a direct tradeoff between reproductive investment and reproductive costs, I determined the relationship between reproductive investment (measured as relative litter mass) and post-partum increase in velocity for both habitat types. I found significant investment-dependent reproductive costs in water ($P = 0.033$), but not on land ($P = 0.142$). These results demonstrate that the cost of reproduction for semi-aquatic organisms may differ between aquatic and terrestrial habitats. For example, swimming may be more effective than crawling for escaping predators during pregnancy because swimming results in a higher absolute velocity and is less impaired by pregnancy than crawling. These results also demonstrate that the assumption of a direct tradeoff between reproductive investment and locomotor impairment may be correct for some, but not all, modes of locomotion.

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Adaptations of a small aquatic snake (*Seminatrix pygaea*) to a dynamic habitat: Selection on body size and reproduction after aestivating during drought

Organisms inhabiting temporary wetlands must be evolutionarily equipped both to survive periodic droughts and to take advantage of seasonal and yearly fluctuations in their prey base and convert that energy intake into successful offspring. The drought survival strategy and reproductive ecology of a small species of semi-aquatic snake (*Seminatrix pygaea*) in an isolated wetland were investigated during the first wet year following a severe drought. Terrestrial drift fence and aquatic trapping data demonstrated that *S. pygaea* remained in aestivation within the dried wetland during the drought. Following the drought, the smallest and largest size classes were absent from the population, suggesting a lack of recruitment during the drought years and selection on body size during long-term aestivation. Nonetheless, during the first wet year following the drought *S. pygaea* capitalized on the abundance of amphibian prey and accrued enough energetic resources to reproduce in the same frequency as in years prior to the drought. Larger females produced larger litters and offspring, suggesting that selection may favor larger females in *S. pygaea* as is typically true of other sexually dimorphic snake species. However, selection during wet years for higher fecundity may be offset by selection for medium sized snakes during aestivation, thus constraining the degree to which sexual dimorphism and body size can increase in *S. pygaea*. Lastly, *S. pygaea* may be atypical among snakes because they readily eat during pregnancy, a trait that may partly explain their unusual ecology and allow them to reproduce during wet years subsequent to extreme droughts.

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South-east Asian biogeography - opening Pandora's box

By far the most pervasive theory to account for the tremendous marine biodiversity found in the area bounded by Sumatra, New Guinea and the Philippines (the so-called Indonesian, South-East Asian or East Indies Triangle) is that it is a Centre of Origin, from which species spread out into the rest of the Indo-Pacific with varying degrees of success. Indeed, this theory has been cited so frequently that it almost regarded as a fact. Yet the evidence for the theory itself has seldom been presented let alone tested empirically. Most studies to date simply assert that it is a centre of origin because it is where most species occur, which is a circular argument when one defines the area where most species occur as the centre of origin. Yet the first biologist to comment lucidly on this region, Alfred Russell Wallace, pointed out that as far east as Bali, the terrestrial fauna is almost entirely SE Asian, but from Lombok, 20 miles away from Bali, the fauna is mostly Australian. Thus, because the triangle area is composed of elements of two entirely different tectonic plates, it is scarcely surprising that it has

considerable diversity - it is not an area at all! It is like saying that Africa and South America must be a centre of origin, because the diversity of the combined faunas probably exceeds even that of the SE Asian Triangle. Our paper will discuss the implications of this thinking, adding to it the far more complex geological origins of the area, and explore old and new techniques of analysing the available information from a historical biogeographic perspective, as well as with approaches we might employ deal with this exceedingly complex situation in the future.

***WINTZER, ALPA P.; WICHMAN, LORI; MARSHALL, MICHAEL J.; CADRETT, PAUL; HEROD, HOLLY B.**

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Fisheries monitoring in California's Central Valley: Trends from a 10-year data set

California's waterways have been the site of large-scale flow manipulations, in an effort to control flood events and to provide irrigation services and drinking water to residents throughout the state. These physical modifications, in conjunction with large numbers of invasive aquatic organisms, have raised concern for several native fish species, including the Sacramento splittail *Pogonichthys macrolepidotus*, longfin smelt *Spirinchus thaleichthys*, Delta smelt *Hypomesus transpacificus*, steelhead trout *Oncorhynchus mykiss*, and both the Winter and Spring runs of Chinook salmon *Oncorhynchus tshawytscha*. The U.S. Fish and Wildlife Service's Stockton office has maintained a fisheries monitoring program since the early 1970's as mitigation both for and with state and federal south delta water export facilities. This program evaluates trends in fish population dynamics and offers real-time data to address water operations and other management policies and decisions. The shorelines of the Lower Sacramento and San Joaquin Rivers, the Delta, and San Francisco Bay, are beach seined at various stations, each of which is sampled 2-4 times per month. Deeper waters are sampled in the Lower Sacramento River, the San Joaquin River, and Chipps Island with either Kodiak or midwater trawls, each of which is fished for ten 20-minute tows between 3 and 7 days per week depending on current monitoring needs. Fishes captured during all sampling efforts are identified to the species level, measured to the nearest mm fork length, and released. Monitoring trends for the afore-mentioned species from the past 10-years are presented and discussed.

***WITZ, BRIAN W.; CONHEADY, MATTHEW**

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Chitinolytic activity of gastric and pancreatic tissue in the side-blotched lizard, *Uta stansburiana*

To determine if the insectivorous side-blotched lizard, *Uta stansburiana*, can digest chitin, extracts from dried gastric and pancreatic tissues were assayed using colorimetry. Tissue extracts from the pancreas and stomach containing the

suspected chitinolytic enzymes were incubated with purified chitin, and an indicator solution (sodium potassium tartate) was used to detect the final product of chitin catabolism, N-acetyl-D-glucosamine (NAG). Chitinolytic activity was detected in concentrations of 0.0127 units/mg in dry gastric tissue and 0.0391 units/mg in dry pancreatic tissue.

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Preliminary examination of risk factors associated with the disappearance of Arizona native ranid frogs (Family Ranidae)

Populations of ranid frogs in western United States, including those in Arizona, have declined dramatically over the past 30 years. Researchers studying these declines have implicated numerous factors, including habitat loss and degradation, predation and/or competition by nonnative species, environmental contamination, diseases, climate change, and increased UVB radiation. These factors have been identified during lab or field experiments or field observations of a few, intensely studied populations over a relatively short period of time. In the arid western United States, extreme variation in local conditions across sites through space and time makes it particularly difficult to measure variables related to population declines in one locality and generalize them to the larger landscape. Therefore, investigating trends in risk across a large number of sites on a larger scale may help discriminate between site-specific factors that are important regionally versus those that are only important locally. If the same factors contribute to declines at multiple sites across a large geographic area, then surviving populations likely share traits that promote persistence, while disappearing populations share traits that increase their susceptibility to decline/disappearance. Identification of environmental and spatial risk factors is useful in understanding the degree and magnitude that different variables contribute to frog declines. Using case-control methods, we examined an observational dataset of ranid frog localities collected by Arizona Game and Fish Department to investigate risk factors associated with population disappearances over time. Elevation, nonnative predators (crayfish and nonnative fish), certain hydrological characteristics (lotic versus lentic), aspect, and effects of nearby sites had a significant effect on whether a population persisted or disappeared.

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Emergence patterns of the Diamondback Terrapin (*Malaclemys terrapin*) in Jamaica Bay Wildlife Refuge, New York City

Diamondback terrapins are estuarine turtles that nest from late May to early August. In Jamaica Bay Wildlife Refuge, New York City, most hatchlings emerge from August until late October, but some may overwinter on land. Laboratory

studies have shown that increased incubation temperatures result in shorter incubation periods. We monitored 87 terrapin nests from oviposition until emergence. Nine nests did not emerge and were left to overwinter. Hatchlings from 78 nests emerged in an average of 70 to 74 days. 66% of nests emerged completely in one to two days, while 18% took more than six days. Emergence periods of more than six days were characterized by a majority of emergence during the first day, followed by a period of inactivity, and finally the emergence of the last one or two hatchlings. Range of emergence periods was not dependent on the size of the clutch. In addition, hatchling emergence was not associated with periods of high rainfall. Hatchlings in nests with warmer incubation temperatures emerged sooner than those in nests with cooler incubation temperatures, leading us to believe that hatchlings developing in warmer temperatures do not remain in nests for long periods of time after hatching.

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A survey of *Uroplatus phantasticus* in Ranomafana National Park, Madagascar

Uroplatus phantasticus is a relatively unknown, cryptic species of nocturnal gecko found in montane rainforests in Madagascar. I conducted visual encounter surveys at night in Ranomafana National Park during the end of the dry winter season and recorded data on body size, perch height and position, and morphology of 26 individuals. I observed one individual ambush prey from a position with its body oriented perpendicular to its perch; 63% (n=33) of the individuals found were in the perpendicular position, rather than being parallel to their perch. If individuals found in a perpendicular position are assumed to be waiting for an ambush opportunity, the data on position frequency may be indicative of how much time *U. phantasticus* spends waiting in ambush as opposed to traveling or resting, activities which are probably more energy efficient in a parallel position. I recorded individuals up to 20% larger than those listed in the existing literature on the species. Additionally, individuals were found at higher perches on average than the literature suggests. Perch diameter was not normally distributed, signifying a preferred perch diameter around the mean. The individuals could be separated into two significantly different groups on the basis of weight and snout-vent length, with the smaller, lighter group comprising more than 75% of the total number of individuals captured. These data appear to represent two age cohorts, the lighter group being sexually immature juveniles, and therefore provide evidence for seasonal reproduction as well as providing insight into juvenile mortality rates and growth rates. More research must be conducted to increase knowledge of the species' behavior and ecology in order for biologists to ascertain the conservation needs and priorities of *Uroplatus phantasticus*, especially in light of the dramatic environmental problems common in Madagascar. **STORER HERPETOLOGY**

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Molecular systematics of the shovelnose sturgeons (Scaphirhynchinae) of North America and central Asia

Among the most imperiled sturgeon species worldwide are those in the subgenus Scaphirhynchinae, referred to as shovelnose sturgeons. These sturgeons are found on two continents; three species within the genus *Scaphirhynchus* in North America and three species within the genus *Pseudoscaphirhynchus* in central Asia. *Scaphirhynchus* species are found in the Mississippi River Basin (including the Missouri River System) and the Mobile Basin, which have been highly modified for navigation, hydroelectric power, and flood control. Species of *Pseudoscaphirhynchus* are endemic to the two main river systems in the Aral Sea Basin, where irrigation has caused the complete dewatering of the lower reaches of the Amu Darya and Syr Darya rivers and the devastation of the Aral Sea ecosystem. Sympatric species of shovelnose sturgeons are found in thousands of river kilometers within the Mississippi River Basin (*S. albus* and *S. platorynchus*) and the Amu Darya System (*P. kaufmanni* and *P. hermanni*). Considerable morphological variation has been documented within each of these species, but none of the intraspecific variants, forms, or clines are clearly defined or currently recognized at a taxonomic level posing potential problems with recovery and conservation efforts. Hybridization between sympatric species in both genera is also a concern. A molecular phylogeny of sturgeon species in these genera, as well as all known morphs of the Eurasian forms has been generated based on mitochondrial DNA sequences. This phylogeny will be presented and discussed along with the implications of these data for management of these poorly understood taxa.

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Amphibian skin peptide defenses against chytridiomycosis, an emerging infectious disease

Chytridiomycosis is an emerging infectious disease of amphibians caused by a chytrid fungus, *Batrachochytrium dendrobatidis* (Bd). This panzootic does not equally affect all amphibian species within an assemblage; some populations decline, others persist. Little is known about the factors that affect disease resistance. Differences in behavior, life-history, biogeography, or immune function may impact survival. We found that an innate immune defense, antimicrobial skin peptides, varied significantly among species within a rainforest stream amphibian assemblage that has not been exposed to Bd. If exposed, all amphibian species at this central Panamanian site are at risk of population declines. In vitro pathogen growth inhibition by peptides from Panamanian species compared with species with known resistance (*Rana pipiens* and *Xenopus laevis*) or susceptibility (*Bufo boreas*) suggests that of the nine species

examined, one species (*Centrolene prosoblepon*) may demonstrate strong resistance, and the other species will have a higher risk of disease-associated population declines. Environmental conditions also influence the antimicrobial defenses of amphibians while at the same time affecting pathogen growth and survival. Bd develops through multiple stages in a single host including a mobile infectious zoospore stage, a sessile developing sporangium, and a zoospore-releasing zoosporangium. As in other organisms with complex life-histories, temperature-regulated trade-offs may exist between growth rate and development rate. Specifically, at 8 degrees C larger numbers of more active zoospores are produced and remain infectious for a longer period of time than at 23 degrees C. However, growth rate is significantly greater at the higher temperature. When these data are applied to a differential model of population growth, the outcome suggests that Bd is well adapted to low temperature conditions, and this corresponds to the observed pattern of chytridiomycosis outbreaks and associated amphibian populations declines at high elevations and during the cold season.

***WOODS, CHRISTOPHER F.; WEBB, JACQUELINE F.; KETTEN, DARLENE R.**

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**The physoclistous swim bladder of chaetodontid butterflyfishes:
Implications for acoustic function**

Butterflyfishes of the genus *Chaetodon* have a swim bladder – lateral line connection (the laterophysic connection, LC), which is thought to enhance the reception of acoustic stimuli by converting sound-induced oscillations of the swim bladder into fluid flow in the lateral line system. Evaluation of LC function is dependent upon an understanding of swim bladder acoustic response, which is dependent on swim bladder morphology as well as mechanisms for control of internal gas pressure. However, the relationship among these factors has received little attention. We used dissection, histology, CT, and SEM to describe the collagenous tunica externa and thin, bilayered tunica interna (including red body [=gas gland + rete mirabile] and the oval gland, responsible for gas secretion and resorption, respectively) in several *Chaetodon* spp. with different LC types, and in non-*Chaetodon* butterflyfishes, which lack an LC. Swim bladder gross morphology and tunica externa thickness differ between *Chaetodon* spp. with direct and indirect LC types; the swim bladder of non-*Chaetodon* spp. resembles *Chaetodon* spp. with an indirect LC. In all species, a collagen-reinforced diaphragm, formed by the inner layer of the tunica interna, divides the gas volume into two chambers connected by a small round opening. The red body is located in the ventral midline of the anterior chamber and its morphology varies interspecifically. The oval gland, defined by an extensive capillary network, is not contained in a small outpocketing of the tunica interna as in published illustrations of the physoclistous swim bladder, but occupies the entire tunica interna of the posterior chamber, which surrounds up to 50% of the swimbladder volume. Chaetodontid swim bladder morphology will be compared with that in other teleost fishes and the acoustic implications of the control of gas pressure in the swimbladder of butterflyfishes will be discussed. Supported by NSF grant IBN-0132607 to JFW.

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Geographical variation in the ontogeny of body shape: a geometric morphometric analysis of the shiner perch *Cymatogaster aggregata* (Labroidei: Embiotocidae)

Cymatogaster aggregata is an extremely abundant near-shore inhabitant, boasting the widest geographic range of any embiotocid, extending from Alaska to Baja. It also occupies a wide range of habitats, varying seasonally from a mid-summer residence in upper estuaries, in which juveniles are born, to a winter or year-round occupancy of marine habitats. This association with estuaries, coupled with the viviparity of embiotocids, predispose them toward a limited dispersal capability and greater partitioning of populations. The potential for greater phenotypic variation is also enhanced by their ecological flexibility. In this study, fish were sampled soon after birth in five localities along the northwestern coast of the U.S.: Friday Harbor, WA; Puget Sound, WA; Willapa Bay, WA; and two localities in Coos Bay, OR. These localities and an additional two (Yaquina Bay, OR, and Humboldt Bay, CA) were sampled in the late summer, about 2-3 months after birth. Using relative warp analyses (Rohlf's TPS software) and multivariate analyses of covariance (MANCOVAs), it is shown that body shape is most distinct among localities early in life, and that growth trajectories differ among localities. Possible causes for the observed geographical patterns are discussed.

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Sexual size dimorphism of the tail in the Alligator Snapping Turtle, *Macrochelys temminckii*

Sexual dimorphism of many turtle species is most apparent in body size, often with females being the larger sex. In *Macrochelys temminckii*, the males attain a larger body size than females. Other than overall size, the primary secondary sexual characteristic associated with male *M. temminckii* is having a longer pre-vent tail length than that of females. *Chelydra serpentina* also exhibits this sexual dimorphism in pre-vent tail length, however, there is no difference between the two sexes in post-vent tail length. It has been hypothesized for *Chelydra* that the elongated male pre-vent tail length can be attributed to three factors in combination: (1) most importantly there is positive allometry of the pre-vent tail region in males; (2) the male plastron shifts anteriorly with respect to the carapace; and (3) the posterior portion of the male plastron grows relatively slower than the entire plastron. In this study, we used measurements of a total of 252 turtles (19 males, 18 females, 190 juveniles, and 25 unknown adults) to examine sexual dimorphism of the tail in *Macrochelys temminckii*. Our data show four growth trends in relation to carapace length (our measure of overall body size): (1) the plastron grows isometrically; (2) total tail length is negatively allometric; (3) in males, pre-vent tail length is positively allometric, while in females pre-vent tail length is isometric; (4) post-vent tail length is negatively allometric in both males and females, but it is more so in males. Our data suggest

that the relative position of the plastron does not play a role in the elongation of the male pre-vent tail length, rather it can be accounted for by positive allometry of the pre-vent tail region in combination with negative allometry of the post-vent tail region.

***WOOTEN, JESSICA A.; RISSLER, LESLIE J.**

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Phylogenetic relationships of the black-bellied salamander, *Desmognathus quadramaculatus*

Phylogenetic relationships were constructed for the black-bellied salamander, *Desmognathus quadramaculatus*. Mitochondrial DNA sequences totaling 694 base pairs for the 12S valine transfer gene were analyzed to create a preliminary phylogenetic hypothesis for relationships within this group. Parsimony and maximum likelihood methods were used to reconstruct the phylogeny. At least four distinct, morphologically cryptic clades were identified: two clades were restricted to separate tributaries in Gilmer County, Georgia; a third clade was restricted to Sullivan County, Tennessee; and the fourth clade consisted of populations throughout West Virginia, Virginia, and northwestern North Carolina. Within these clades, there was no apparent indication of distinguishable morphological characteristics, with the exception of body size, which has been shown to be phenotypically plastic. Drainage patterns and other physiographic features were also examined by KH, SOWH tests in PAUP and AMOVA in Arlequin to determine the potential factors affecting genetic divergence. This research provides insight to the phylogeographic patterns throughout the entire range of *D. quadramaculatus* and may lead to the identification of unique genetic lineages that may deserve species status.

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Electroreception of rhinobatids

Electroreception is a phylogenetically old sensory modality found amongst fishes, amphibians and mammals. Elasmobranchs use their electroreceptive structures, the ampullae of Lorenzini (each consisting of a canal connecting an ampulla with a somatic pore), during foraging, social interactions and orientation in the earth's magnetic field. In this study, I comprehensively described the electrosensory system of *Rhinobatos typus* and *Aptychotrema rostrata*, two rhinobatids commonly found on sandy bottoms in shallow coastal habitats of South East Queensland, Australia. The electrosensory system of both species was mapped and ampullae were processed for light and transmission electron microscopy. I found basic pore patterns to be similar for both species, with 85.7% of pores located on the ventral side of the disk in *Rhinobatos typus* and 80.4% in *Aptychotrema rostrata*. The highest densities of pores were found ventrally along the rostrum, around the mouth and in the area surrounded by gills, mouth and abdominal lateral line canal. Ampullae of the ventral side of the rostrum possess

short canals (7.3 ± 2.8 mm in *R. typus* and 8.9 ± 3.4 mm in *A. rostrata*) compared to long canals leading to pores on the pectorals (22.5 ± 7.5 mm in *R. typus* and 23.4 ± 9.6 mm in *A. rostrata*). Behavioural studies to identify the intensity of electric fields used in detection of prey are ongoing. Further study of these complex systems is warranted and would help to increase our knowledge of the food sensing abilities of elasmobranchs in general. **AES CARRIER**

***WUSTERBARTH, THERESA L.; KING, RICHARD B.; DUVALL, MELVIN R.; GRAYBURN, W. SCOTT; BURGHARDT, GORDON M.**
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All the right moves: Phylogenetically widespread natricine promiscuity

Promiscuity and the occurrence of multiple paternity within litters of offspring are characteristic of many species within the animal kingdom, and are analogous to the mating strategies of cross-pollinating plants. Specific knowledge of reptile mating systems, however, is lacking. Previous independent investigations determined multiple paternity to be characteristic of four disjunct natricine snake species, including *Thamnophis sirtalis*, *Nerodia sipedon*, *Thamnophis butleri*, and *Thamnophis elegans*. We investigated the various untested clades and subclades of North American natricine snakes to determine the phylogenetic extent of multiple paternity within this subfamily. Representative species tested included members of the semifossorial clade (*Storeria dekayi*, *Storeria occipitomaculata*), watersnake clade (*Nerodia rhombifer*, *Regina septemvittata*) and gartersnake clade (*Thamnophis radix* - widespread subclade; *Thamnophis sauritus* - ribbon and common gartersnake subclade; *Thamnophis melanogaster* - Mexican subclade). Using primers originally developed for *Thamnophis* and *Nerodia*, DNA from litters with known mothers was amplified at highly variable microsatellite loci. After identifying maternal alleles in offspring genotypes, the number of paternal alleles per litter was counted. The presence of more than two paternal alleles (the maximum when a sire is heterozygous) within any single litter indicated that multiple paternity is widespread throughout Natricinae, with the exception of the Mexican subclade, represented by *T. melanogaster*. This study is the first to examine multiple paternity across a widespread, related group of vertebrates.

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Chronology of breeding migrations of five ambystomatid salamanders, in a complex wetland community

Arnold Air Force Base is a highly diverse area of the Barrens region of Tennessee and is home to many threatened and endangered plants and animals. Surveys of the base's herpetofauna have identified a diverse community of reptiles and amphibians. Drift-fence / pitfall arrays along with minnow traps were placed in and around an entire wetland at Arnold Air Force Base, TN. Five species of ambystomatids were found utilizing the wetland as a breeding habitat along with 14 other amphibian and 9 reptile species. *Ambystoma opacum* entered the wetland first in mid September (Sep 17th thru Oct 5th) and emigrated out in the first week of November (Nov 5th) with metamorphosed individuals leaving the wetland in mid May (May 15th). *Ambystoma talpoideum* immigrated to the wetland in mid January (Jan 9th thru Jan 29th) and emigrated in mid April (Apr 13th thru Apr 26th). *Ambystoma maculatum* immigrated to the wetland in late January (Jan 30th thru Feb 12th) and emigrated at the first of March (Mar 2nd and 3rd). *Ambystoma tigrinum* immigrated to the breeding site in early February (Feb 4th thru 14th) and emigrated in mid March (Mar 16th), with metamorphosed individuals leaving the site on July 14. *Ambystoma texanum* immigrated to the breeding site in early February (Feb 6th thru 14th) and emigrated in early March (Mar 2nd and 3rd). The presence of five ambystomatid salamanders breeding in one site is rare and sets up a highly competitive community.

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Transient anatomical features of *Scyliorhinus torazame* embryos

Fertile *Scyliorhinus torazame* ova require 210 days to complete embryonic development at 14-16 °C. During this time the embryo and egg case continually adapt to each other. Embryos possess transient structures specialized for development within the egg case. In common with other oviparous elasmobranchs, gill filaments and the external yolk sac surface provide surface area for oxygen transfer. Both remain prominent features of embryos until buccal respiration commences. The egg case respiratory slits are opened by the action of the hatching gland 101 days after oviposition. Next, specialized primary scales found in two rows at the dorsal and ventral margin of both sides of the caudal fin erupt. The tip of the caudal fin is an extension of the notochord and forms a concave scoop for water transfer through the egg case by active pumping of the tail. Embryos have been observed to project this tail extension through the hatching terminus of the egg case in the months preceding hatching. The cup-like

extension and caudal scales can be observed in embryos after eclosion but are gradually resorbed during the following months. The final specialized embryonic structure to develop are primary scales found in 2 dorsolateral rows along the trunk. These scales erupt before hatching and may be used to aid in escape from the egg case during eclosion. Ordinary placoid scales do not erupt until after hatching.

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Developmental abnormalities in *Scyliorhinus torazame*

Scyliorhinus torazame is an oviparous elasmobranch found year-round in the western Pacific continental shelf. It is easily maintained in captivity and readily reproduces. A single pair of eggs is laid every 20-30 days and development to hatching requires 210 days at 14-16 °C. Beginning in May, 2004, eggs from 3 females at Hekinan Seaside Aquarium, Aichi, Japan, were collected for an analysis of embryonic development. The percentage of fertile eggs was 75%, 83% and 23% for females 1, 2 and 3 respectively. Fertile ova were monitored daily for developmental progress. Each female had ova that experienced terminal abnormalities during their development. All abnormal embryos except one successfully completed gastrulation. Failure to complete epiboly was a common occurrence and resulted in a ruptured ovum with a contracted blastoderm surrounding the embryo. Most abnormalities were seen in the developing tail and occurred concurrent with vascularization of the yolk sac. One remarkable embryo survived more than 3 months with no blood cells circulating within its blood vascular system despite the presence of a beating heart. The percentage of abnormal embryos observed was 17%, 10% and 33% for females 1, 2 and 3 respectively. The reasons for the observed developmental abnormalities are unknown but several factors may contribute including age of female, interval of last mating, water quality, sperm quality and interbreeding.

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Reassessing Loggerhead Sea Turtle sex ratios: Empirical measures, novel discoveries

Loggerhead sea turtles (*Caretta caretta*), nest on the US Atlantic coast and Gulf of Mexico beaches. The females at these rookeries have subpopulation level structuring; these subpopulations include a reasonably small and still declining (2-3% per year) northern subpopulation and a 10-fold larger and stable or slightly declining southern subpopulation. Most loggerhead nesting occurs along the midAtlantic seaboard between North Carolina and Florida. Because sea turtle

sex is environmentally determined and warmer incubation temperatures are associated with female based sex ratios, we predicted that the southern subpopulation would be strongly female-dominated, while the northern population would be male-dominated. We modified existing laparoscopic procedures to determine the sex of more than 1600 posthatchling (approx. 120g) loggerhead sea turtles from 10 beaches representing both NW Atlantic subpopulations (in 2002-2004). Our techniques for determining sex using nonlethal laparoscopy were 96-99% accurate based upon micro-biopsy verification. Contrary to expectations, more females came from northern nests and more males came from southern nests in 2002. In 2003-2004, the opposite was true. The high proportion of males at some southern subpopulation sites was particularly surprising. Once the sex ratios were scaled to beach production, there remained an overall female bias. However, sex ratios among years differed dramatically from one another and the intermittent contribution of male hatchlings from the large Florida subpopulation prevented a severe female bias in hatchling production.

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Gopher tortoise (*Gopherus polyphemus*) habitat restoration in pine forests using prescribed fire on Camp Shelby Training Site, MS

Shrub encroachment and herbaceous decline during periods of fire suppression have resulted in degraded habitat conditions for gopher tortoises (*Gopherus polyphemus*) in many southeastern pine forests. As forested habitat quality declines, gopher tortoises often move into anthropogenically-maintained, open herbaceous areas such as right-of-ways and training areas to the detriment of the animal and land manager. To evaluate whether prescribed fire could restore degraded forest habitat conditions around military training areas on Camp Shelby Training Site, MS, we sampled vegetation in 8 degraded forest sites adjacent to training areas each June from 2001-2004. Four sites were burned during the winter of 2001/2002 (dormant season) and again in April 2003 (growing season); 4 control sites were not burned. Leguminous cover did not differ between treatments or among years. Woody cover was reduced on burned sites in 2003; however, shrub cover rebounded and there were greater shrub stem densities on burned sites compared to controls in 2004. Total herbaceous, forb and graminoid cover did not increase on burned sites post-burning. These results suggest that a simple reintroduction of fire into degraded forest habitat may not rapidly restore desired habitat conditions (open canopy, sparse woody midstory, and abundant herbaceous vegetation). Several consecutive annual burns or other management techniques may be necessary. However, during the course of the study total herbaceous, forb and graminoid cover declined on control sites and post-burning was greater on burned sites compared to control sites. This suggests that burn treatments may at least prevent further deterioration of habitat conditions.

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Habitat utilization by multiple coastal shark species in a salt marsh nursery

Southeastern coastal shark species utilize shallow, highly productive nearshore waters, estuaries, and inlets as nursery grounds from early spring to fall. This study examined the temporal and spatial partitioning of multiple shark species within one salt marsh nursery ground in South Carolina and further investigated the effect of creek size and tide on shark occurrence. A total of 74 sharks were caught on 256 demersal longlines from April through October of 2004 in North Inlet Estuary. Seven species were represented: *Rhizoprionodon terraenovae*, *Carcharhinus limbatus*, *Sphyrna tiburo*, *Negaprion brevirostris*, *C. plumbeus*, *C. acronotus* and *C. isodon*. Longline effort was equal for both high and low tide and large and small creeks (mean width \pm SE: 106.7 ± 23.3 m and 35.3 ± 2.3 m, respectively). We observed staggered peaks of abundance for species throughout the sampling season, indicating that shark species in this system exhibit temporal partitioning. The abundance of neonate *R. terraenovae* in June suggests North Inlet serves as a primary nursery ground for this species. Hierarchical loglinear analysis found the interaction of creek size and tide significantly affected shark occurrence. Further research on factors influencing shark habitat selection is necessary to understand their habitat requirements at all life stages and to apply effective management strategies.

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Examination of winter grounds for blacktip sharks, *Carcharhinus limbatus*, in Florida

Nursery areas for neonate and juvenile blacktip sharks (*Carcharhinus limbatus*) have been well studied along the Gulf coast of Florida, but the location of wintering grounds for this species has yet to be identified. Recapture data from sharks tagged along the central Gulf coast suggest that young blacktip sharks migrate south to or through Florida Bay and the Florida Keys. Similar data from northwest Florida also suggests movement to the south (up to 205 nautical miles) by juvenile sharks during winter months. However, this data is limited and the location of winter grounds in the northern Gulf of Mexico is unknown. To fill these gaps in our knowledge a research project was developed to target young blacktip sharks during winter months to identify potential winter grounds. This project incorporated the aid of local charter fishermen along the panhandle and in Florida Bay and the Florida Keys. Charter fishermen were trained to tag sharks as cooperative partners in the project. From December 2004 through March 2005 blacktip sharks were captured and tagged with conventional tags. In addition, pop-off archival satellite tags were deployed on two larger individuals to determine if they would move into the central or northern Gulf of Mexico during summer months. Winter habitat preference, tag recaptures, and satellite

tag results will be presented.

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Alternative conceptions in animal classification: A cross-age study focuses in amphibians and reptiles

This study examined students' alternative conceptions of reptiles and amphibian and the extent to which these conceptions remain intact through the elementary (3-4 grade and 5-6 grade), junior, and senior high school students. We administered multiple-choice and free-response instruments to a total of 410 students. We also interviewed at least 20 students at each education level to get in-depth view of original conceptions. Then, we developed and applied a two-tier multiple choice diagnostic instrument to assess various level of students in understanding of the amphibian and reptile. The result showed that most students were able to classify snakes as reptiles, whereas less than 30% of the students across different ages classified sea turtles as reptiles, and the remaining 70 % classified sea turtles as amphibians. More students were able to classify frogs as amphibians than they did on toads. Interestingly, the alternative views of sea turtles as amphibians remained intact throughout the school years. Interview data indicated that students classified sea turtles as amphibians largely due to the fact that sea turtles are able to live in terrestrial and aquatic habitats. Semantically, "amphi-" means living on land and in water. When asked to distinguish between reptiles and amphibians and to classify several species into those two groups, a wide range of alternative conceptions also emerged and the origin of those alternative conceptions were discussed. A similar results was obtained when we applied a two-tier multiple choice diagnostic instrument to assess students' understanding of the amphibian and reptile in various level of students.

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Comparative morphometrics of the elasmobranch brain: Mapping neuromorphology onto behavior and environment

There is widespread variation in both brain size and complexity across the elasmobranch phylogeny. The relative brain weight of a species is dependent upon the enlargement or regression of individual brain structures, some of which can be identified with different sensory modalities and behaviors. We hypothesize that the degree of development of these brain structures is related to the relative development of sensory modalities and behaviors, which can in turn be related to the environment the animal inhabits. A total of 28 species from 16 families were collected from 3 localities in Australasia. Each brain was sectioned and the cross sections scanned using Sigma Scan® digital analysis program to produce weights of the individual brain structures. In addition, an index (1-5) of structural complexity of the cerebellum was created based on length, number,

and depth of folds. The data show large variations in relative brain weight and complexity between species that do not follow a simple phylogenetic pattern. Pelagic sharks that move in 3-D space and hunt agile prey, such as *Isurus oxyrinchus* and *Prionace glauca*, have a similar structural hypertrophy with large, foliated cerebella (index grade 4-5) and enhanced telencephalons. In comparison, benthic and bathyal sharks, such as *Notorhynchus cepedianus* and *Cephaloscyllium isabella*, operate more in a 2-D environment and have a small, smooth corpus (index grade 1-2) and enlarged centers for electroreception and lateral line. Benthopelagic sharks, such as *Mustelus lenticulatus* and *Carcharhinus brachyurus*, fall in the middle of these two extremes in neuroanatomical development. It appears that brain development reflects the dimensionality of the environment and/or agile prey capture rather than phylogeny. One focus of our interest in morphometrics is the cerebellum and the controversy surrounding its function. Though principally associated with motor control, the alternative hypothesized function is that of active sensory exploration and target tracking; our morphometric data is consistent with either view. **AES GRUBER**

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Response of the yellow anaconda, *Eunectes notaeus*, to aquatic pressure waves

Previous research has shown that snakes can behaviorally respond to both airborne and groundborne vibration, and that their response is dependent on behavioral context. The present study examined whether or not snakes could also respond to pressure waves in water. This study involved the yellow anaconda, *Eunectes notaeus*, a large, primarily aquatic, ambush predator that frequently takes its vertebrate prey from the water surface. *Eunectes* tends to inhabit waters with moderate to high turbidity, suggesting that visual cues may be of reduced importance for prey localization. The pressure waves produced by a mouse swimming in water were recorded using a hydrophone, and clean segments of multiple recordings edited together to create a continuous loop that was used as a trial stimulus. Playback experiments were conducted using a submerged speaker and five long-term captive, juvenile snakes. Presentation of the trial stimulus provoked a clear and directed predatory response. In a second experiment a remotely-activated solenoid was used to drop a lead weight toward the water surface of the tank holding the anaconda. In half the trials the lead weight was painted for maximum contrast against the background and was suspended by a bungee-like cord so that it did not actually contact the water surface but would repeatedly bob up and down directly over the water. In the other half of the trials the lead weight was painted to match the background and was allowed to drop freely into the water and to sink into a padded cradle that prevented the weight from striking the bottom of the tank. The *Eunectes* showed no reaction to the visual stimuli of the "bobbing" weight, but reacted defensively to the trials using the "sinking" weight. The results of these experiments demonstrate that *E. notaeus* is capable of detecting, and responding to, aquatic pressure waves.

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Mechanisms controlling venom expulsion in the Western Diamondback Rattlesnake, *Crotalus atrox*

Although many studies have documented variation in the amount of venom expended during bites of venomous snakes, the mechanistic source of this variation remains uncertain. This study used experimental techniques to examine how two different features of the venom delivery system, the muscle surrounding the venom gland (the Compressor Glandulae in the rattlesnake) and the fang sheath, could influence venom flow in the western diamondback rattlesnake, *Crotalus atrox*. Differential contraction of the Compressor Glandulae explained only approximately 30% of the variation in venom flow. Lifting (compression) of the fang sheath as occurs during a normal strike produced marked increases in venom flow; these changes were closely correlated and exceed in magnitude by almost 10 x those recorded from the Compressor Glandulae alone. These results suggest that variation in these two aspects of the venom delivery system, both in terms of magnitude and temporal patterning, explain most of the observed variation in venom injection. The lack of functional or mechanical links between the Compressor Glandulae and the fang sheath, and the lack of skeletal or smooth muscle within the fang sheath, make it unlikely that variation in venom flow is under direct neural control. Instead, differential venom injection results from differences in the pressurization by the Compressor Glandulae, the gate keeping effects of the fang sheath and enclosed soft-tissue chambers, and by differences in the pressure returned by peripheral resistance of the target tissue.

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The conservation status of New World amphibians

Application of the IUCN Red List criteria to all 3,046 species of New World amphibians reveals that 39% of species are threatened with extinction (IUCN categories Vulnerable, Endangered, and Critically Endangered) and nine have already gone extinct. Of the 337 species assigned to the highest threat category (Critically Endangered), 117 have not been seen in the past 10-20 years and are feared extinct. Threatened species are not distributed evenly throughout the hemisphere: Amphibian fauna occurring on isolated mountains in the Caribbean, in highlands from Mexico south through the northern Andes, and in the Atlantic forest of Brazil are most threatened. North American species are, on average, the least threatened of the New World, in part due to ongoing conservation measures. Natural history correlates of threat status include occurrence at high elevations and restricted range size. Among the factors causing declines, habitat

loss was the most pervasive, affecting 89% of all threatened species. The chytrid fungal disease, *Batrachochytrium dendrobatidis*, is known or suspected to have caused declines in nearly half (47%) of all Critically Endangered species. The hemisphere's system of protected areas plays an important role in protecting amphibians from habitat destruction, but more than a third (37%) of all threatened species do not occur within any protected area. These results, compiled as part of the Global Amphibian Assessment, underscore the breadth of amphibian declines both taxonomically and geographically in the New World. Urgently needed conservation measures include the establishment of preserves for currently unprotected threatened species and research on ways to stem chytrid epidemics in the field.

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Effects of turbidity on reactive distance and capture success in the drift feeding stream minnow, Rosyside Dace (*Clinostomus funduloides*)

Turbidity is the standard method of quantification of suspended sediments in streams. Since the turn of the 20th century the Southeast has experienced increased stream sediment loads. Unfortunately, the effects of turbidity on non-game drift feeding fishes (i.e., majority of fishes in many streams) are not well understood due to a limited number of studies. Consequently, we examined the effects of turbidity (levels found in southeastern streams) on foraging success in rosyside dace (*Clinostomus funduloides*), a species of special concern in the southeastern US. Experiments were conducted in an artificial stream and reactive distance (the distance from a fish to a prey item when a fish first reacts to it) and prey capture success (the number of prey successfully captured) were recorded. Regression analysis indicated that turbidity had a strong negative effect on both reactive distance ($R^2=0.91$) and capture success ($R^2=0.79$). Analysis of variance also indicated a significant effect in both cases ($p < 0.0001$). At the highest level of turbidity tested (55 NTU) reactive distance was 21% of maximum and capture success was 5% of maximum. Rosyside dace in undisturbed reaches of the Little Tennessee drainage, rarely experience turbidity levels high enough to negatively affect foraging success. However, impacted reaches exhibit turbidity levels that had negative impacts on foraging success approximately 50% of the time. These results indicate that foraging success in rosyside dace is reduced in turbid conditions and suggest that further studies of the effect of increased stream sediment loads and turbidity on non-game drift feeding fishes are necessary.

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The use of mitochondrial DNA to determine the population structure of triptetail, *Lobotes suvannanensis*, in the northern Gulf of Mexico

The increasing popularity of triptetail as a recreational sport fish in the northern Gulf of Mexico conceals fisheries biologists due to the lack of information on

Cancelled

population structure for the species. Many recreational fisheries use molecular genetic analysis to help manage sport fish populations. Identifying molecular markers for tripletail in the northern Gulf of Mexico will help to determine their population structure, thus providing recreational fisheries management with adequate information for future monitoring and conservation. The goals of this study are to: 1) determine the appropriate region of the mitochondrial genome that would serve as a suitable marker for population genetic studies of tripletail; and 2) use this marker to determine the population structure (distinct vs. homogeneous populations) of tripletail in the northern Gulf of Mexico. Adult tripletails sampled for genetic analysis were collected by hook and line, while juveniles (>3cm) were collected with kick nets. Work is currently in progress for this project, but we have already used PCR to successfully amplify several mitochondrial genes (COI and cytb). Based on our experiences with other fishes, these genes should prove adequate to resolve any stock structure that might be present. **STORER ICHTHYOLOGY**

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Behavioral thermoregulation of the leopard shark, *Triakis semifasciata*, in nearshore embayments of Catalina Island, California

The leopard shark, *Triakis semifasciata*, is one of the most abundant nearshore elasmobranchs ranging from Baja California, Mexico to Oregon, with particular abundance in the bays of California. Mature female leopard sharks have been observed aggregating in Big Fishermans Cove (BFC) Santa Catalina Island for over 100 years; however, it is unclear why females aggregate in these shallow areas. During July and August of 2003, the numbers of aggregating sharks were counted in different sections of the shallow embayment of BFC during the day ($n = 36$, mean = 21.52 ± 8.17). Water temperature was simultaneously monitored in each section of the embayment. Temperatures in the embayment ranged from 17.8°C to 25.8°C (mean = $21.8^{\circ}\text{C} \pm 1.2$). Sharks preferred the warmest sampling areas of the embayment (correlation $r = 0.557$, $p \leq 0.01$) and moved to warmer locations over the course of the day. These results suggest that leopard sharks are utilizing the warm water of the embayment to behaviorally thermoregulate. Currently manual acoustic tracking, acoustic monitoring and archival transponder technology (Vemco Ltd., V13, V13-R256, VX32TP-Chat tags respectively) are being used to monitor body temperature, swimming depth, and movements of mature female leopard sharks at Catalina Island ($n=16$). Passive acoustic monitor data demonstrates that these sharks show increased fidelity to thermal refuges around the island during the day and increase movement away from these refuges at night (2, $p=0.01$). Preliminary results from the Chat tags suggest that shark body temperature is warmer when in shallow water (correlation $r=0.43$, $p \leq 0.01$), and that shark body temperature is warmer during the day than at night (2, $p=0.01$). Behavioral thermoregulation, as suggested by these results, may augment metabolic and physiological functions such as digestion, foraging behavior, and possibly reproduction.

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Conservation genetics of the frog *Eleutherodactylus ranoides* (*Rugulosus* group) in Guanacaste, Costa Rica

The *Eleutherodactylus rugulosus* complex is one of the groups of amphibians most affected by population declines. Its species are essentially nocturnal and inhabit slow-flowing, rocky streams. There are eight species described for Costa Rica, the majority of which lacking observation records for the last two decades.

Eleutherodactylus ranoides was once a very common species in Costa Rica, but it has not been observed in the last 20 years. In April of 2003, one population was nonetheless recorded at Murcielago river, Santa Rosa National Park (Murcielago Sector, Guanacaste). In 2005, three new groups were found at La Calera river, Potrero Grande river and Quebrada la Danta, which corresponds to an effluent of the Potrero Grande river. These three sites are located in Santa Rosa National Park, on the Santa Elena Peninsula. The presence of a population at Murcielago river was confirmed in 2005. Applications of conservation and population genetics will help us obtain a genetic diagnosis for this species, enabling us to design a regional conservation project. Currently, we are planning to use microsatellites and perhaps DNAmT to find if local populations constitute a metapopulation connected via gene flow, or, alternatively, if they correspond to isolated populations. Microsatellites can demonstrate low or high genetic flux among groups, and will inform us about the amount of local genetic variation through a quantification of alleles observed per locus.

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