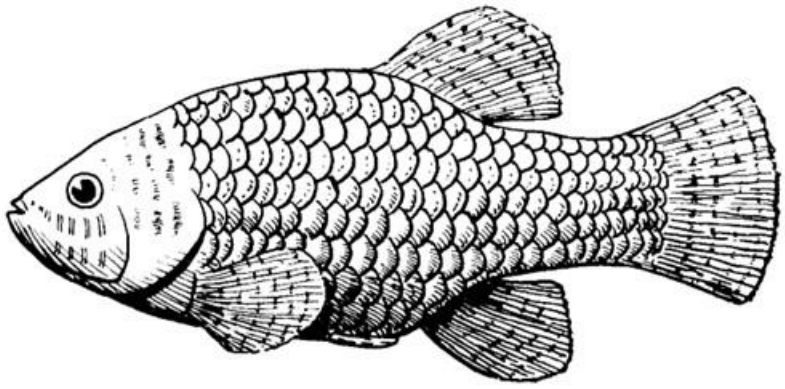
DESERT FISHES COUNCIL 54TH ANNUAL SYMPOSIUM, 2022 – ST. GEORGE, UTAH
LONG PROGRAM



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VIRGIN RIVER PROGRAM

THANKS TO LOCAL HOSTS & MEETING ORGANIZERS KRISSY WILSON & RICHARD FRIDELL!

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DESERT FISHES COUNCIL 54TH ANNUAL SYMPOSIUM, 2022 – ST. GEORGE, UTAH – SHORT PROGRAM

WEDNESDAY AFTERNOON, NOVEMBER 16 – MAIN CONFERENCE ROOM

16:00-19:00: Registration

16:00-19:00: Presentation loading in person (if not emailed ahead of time)

18:00-20:00: Social Mixer with snacks provided – main conference room

THURSDAY MORNING, NOVEMBER 17 – MAIN CONFERENCE ROOM

07:30-08:30: Presentation loading in person (if not emailed ahead of time)

07:30-12:00: Registration

08:30-08:45: Welcome – Kevin Wilson, President; Krissy Wilson & Richard Fridell, Local Hosts

Virgin River Symposium *- Conservation Challenges in the Nation's Fastest Growing Metropolitan Area – Plenary Session – Moderator Rick Fridell*

08:45-09:05: Collaborative partnerships: the key to successful conservation planning in America's fastest growing metropolitan area – **Rick Fridell, Melinda Bennion, Martin Schijf, Kody Callister, Sarah Siefken, & Erik Woodhouse**

Washington County has been the fastest growing county in Utah over the previous 30 years and one of fastest growing areas by percentage in the United States. The current growth rate of St. George is above 19% making it the fastest growing small metro area in the United States in 2022. This rapid population growth is projected to continue well into the foreseeable future. Washington County lies at the intersection of the Mohave Desert, Great Basin, and Colorado Plateau leading to a diverse mosaic of habitats and making it the most biological diverse area in Utah. Land and water development to accommodate rapid growth coupled with this unique biological diversity has led to the potential for conflicts between economic development and sensitive / endangered species conservation. Several largescale collaborative programs between local, state, and federal entities have been established to manage these potential conflicts. We will provide a summary of many of these long-term cooperative planning efforts including the Virgin River Resource Management and Recovery Program and the Washington County Habitat Conservation Plan. Thoughtful land use and water development planning is instrumental in continuing to find solutions to maintain quality of life for the human population while enhancing sensitive wildlife and aquatic species habitat.

09:05-09:25: Efficient Water Management for People & Wildlife, Virgin River, Utah – **Elaine York**

As a member of the Virgin River Program (VRP) administrative committee, The Nature Conservancy (TNC) supports this collaboration of federal, state and local partners to conserve the unique Virgin River ecosystem – important habitat for six native fish, southwestern willow flycatcher, and many other wildlife species. The River is also a critical water source for a rapidly growing human population. Our goal is to work closely with VRP partners on approaches to conserve native species while still providing water for human needs. To date we've partnered in several ways: 1) providing funds to identify river flows needed to maintain healthy summer water temperatures for the woundfin, 2) acquiring some critical river properties that are managed for native fish and other wildlife, and 3) financially supporting a 5-year Santa Clara river water lease to benefit the Virgin spinedace. One of our most complicated Virgin River projects has been obtaining federal funding to implement three Virgin River projects, one being the modernization of Hurricane's water delivery system to provide additional flows for the

Virgin River below the town of Hurricane, critical habitat for the woundfin and Virgin River chub. The presentation will explain some of the goals and challenges with this ongoing project.

09:25-09:45: The Virgin River Resource Management & Recovery Program: 20 years of Conservation & Recovery – **Josh Rasmussen**

The Virgin River Resource Management and Recovery Program (Program) was established by agreement of federal, state, and local agencies in 2002. The goals of the program are to 1) recover, conserve, protect, and enhance native species in the upper Virgin River Basin (i.e., the Virgin River drainage within Utah), and 2) enhance the ability to provide adequate water supplies for sustaining human needs in the same area. To accomplish these goals, the Program relies on recovery documents for the Virgin River Chub, *Gila seminuda*, the Woundfin, *Plagopterus argentissimus*, the Southwestern Willow Flycatcher, *Empidonax traillii extimus*, and the Virgin Spinedace, *Lepidomeda mollispinis*, Conservation Agreement and Strategy. Similarly, the Program adheres to the Virgin River Management Plan, so long as the actions are in line with the Program's stated goals. In the past 20 years of continuous operation, Program partners have successfully supported conservation of the Virgin Spinedace such that protection of the species under the federal Endangered Species Act was found not warranted twice. The occupied habitat of the species has increased from 60 to 90 percent. Also, the invasive Red Shiner, *Cyprinella lutrensis*, has been eradicated from the Program Area, i.e., the Virgin River drainage within Utah, over 65 miles of river habitat. The Program substantively supports propagation for the listed fish species and diverse restoration, research, and management efforts throughout the basin. The Program successfully utilizes partnerships to advance the recovery of listed species.

09:45-10:05: The Virgin Spinedace Conservation Agreement & Strategy: Twenty-seven years of conservation success – **Rick Fridell, Martin Schijf, & Christian Edwards**

The Virgin Spinedace, *Lepidomeda mollispinis*, is a minnow endemic to the Virgin River Basin. By 1994, threats to the species reduced Virgin Spinedace populations to approximately 60% of their historic distribution. As a result of these threats, the Virgin Spinedace was proposed for listing in 1994 as a threatened species under the Endangered Species Act (ESA). The Virgin Spinedace Conservation Agreement and Strategy (VSCAS) was developed in 1995 in accordance with the ESA to improve conditions resulting in the decline of Virgin Spinedace, enhance habitat, and re-establish locally extirpated populations throughout the Virgin River Basin. When implemented, management actions outlined in the VSCAS would alleviate factors warranting listing under the ESA. The primary goal of the VSCAS is to increase the range of the species from 60% to at least 80% of its historically occupied habitat. Conservation measures by local, state, and federal partners have restored flows and spinedace habitat to the Santa Clara River, Beaver Dam Wash, Quail Creek and other tributaries in the Virgin River Basin. Conservation actions implemented over the last twenty-seven years to successfully restore the Virgin Spinedace throughout their range include restoring stream flow and connectivity, removing in-stream barriers, re-establishing fish populations, purchasing flood plain and aquatic habitat, and managing non-native species. Cooperative partnerships under the VSCAS have restored Spinedace to over 90% of their historic range.

10:05-10:15: **BREAK**

Virgin River Session – *Moderator Rick Fridell*

10:15-10:30: Virgin Spinedace Restoration in the Santa Clara River below Gunlock Reservoir – **Martin Schijf, Rick Fridell, Christian Edwards, Melinda Bennion, Erik Woodhouse, Kody Callister, & Sarah Siefken**

The Virgin Spinedace, *Lepidomeda mollispinis*, is a minnow endemic to the Virgin River Basin. In 1994, the species was proposed for federal listing under the Endangered Species Act (ESA) due to population declines resulting from habitat loss and degradation. At the time of the listing proposal, Virgin Spinedace distribution had declined to approximately 60% of its historic distribution within the Virgin River Basin. In response to the proposed federal listing, the Virgin Spinedace Conservation Agreement and Strategy (VSCAS) was initiated in 1995. The VSCAS was critical in establishing collaborative partnerships to provide resources and cooperative efforts to conserve and enhance Virgin Spinedace populations throughout their range. The VSCAS outlines conservation actions intended to reverse declines and enhance Virgin Spinedace by protecting and expanding extant populations and reestablishing extirpated populations. One of the primary goals of the VSCAS was to increase the range of Virgin Spinedace from 60% to at least 80% (~ 185 km; 115 mi of linear riverine habitat) of its historically occupied habitat by protecting and expanding extant populations and re-establishing extirpated populations. The U.S. Fish and Wildlife Service determined that full implementation of management actions outlined in the VSCAS would alleviate the factors that led to the decline in Virgin Spinedace populations, and eliminate the necessity for an ESA listing. Restoration of population maintenance flows to reestablish viable Virgin Spinedace populations in dewatered or depleted stream reaches is a primary objective in the VSCAS. The Santa Clara River below Gunlock Reservoir was identified as a key Virgin Spinedace restoration reach. Our presentation outlines the success of collaborative efforts implemented by VSCAS signatories and other key partners to restore population maintenance flows and Virgin Spinedace populations in the Santa Clara River below Gunlock Reservoir.

10:30-10:45: Limiting Factors & Recovery of Woundfin in the Virgin River – **Melinda Bennion, Rick Fridell, Martin Schijf, & Kody Callister**

Woundfin, *Plagopterus argentissimus*, have been federally listed as an endangered species since 1970. Successful reproduction and recruitment of Woundfin is limited to a 16.3 mile reach in the upper Virgin River in Utah. Until recently, only a small portion of Woundfin live to be greater than 1-year old in the wild; the persistence of Woundfin is dependent on the survival and reproductive success of these young fish. Woundfin abundance and distribution has been limited by multiple factors including non-native fish, drought, altered streamflow regimes, diversions, elevated water temperature, decreased turbidity, water management events, and a decline of spawning and rearing habitat.

Since 2000, Utah Division of Wildlife Resources has worked through the collaborative Virgin River Program to identify and evaluate factors limiting Woundfin persistence and recruitment. This presentation will highlight the creative ways we have addressed these limiting factors and discuss how Woundfin populations have responded.

10:45-11:00: Non-native Fishes Management in the Virgin River Basin, Utah – **Erik Woodhouse, Rick Fridell, Martin Schijf, Melinda Bennion, Christian Edwards, Kody Callister, & Sarah Siefken**

The Virgin River, located in southwestern Utah, supports two federally endangered fishes including Woundfin, *Plagopterus argentissimus* and Virgin River Chub, *Gila seminuda*. Additionally, four other native fishes inhabit the Virgin River Basin, including Virgin Spinedace, *Lepidomeda mollispinis*, Speckled Dace, *Rhinichthys osculus*, Desert Sucker, *Catostomus clarkii*, and Flannelmouth Sucker, *Catostomus latipinnis*. The introduction of many non-native fishes in the Virgin River Basin has greatly reduced native fishes populations basin-wide through predation, competition for resources, and disease. The management of non-native fishes through intensive monitoring, chemical and mechanical eradication efforts, and public outreach are key components to the recovery and conservation of these native fishes. This presentation will highlight the efforts of the Utah Division of Wildlife Resources in collaboration with local and federal partners through the Virgin River Program to manage non-native fishes in the Virgin River Basin identifying current and historical non-native fishes, non-native monitoring and eradication efforts, and public outreach aimed at preventing future non-native fishes introductions.

11:00-11:15: Red Shiner Eradication: A History of Endangered Species Recovery through Non-Native Removal in the Virgin River – **Sarah Siefken, Rick Fridell, Kevin Wheeler, Melinda Bennion, Martin Schijf, Christian Edwards, Erik Woodhouse, & Kody Callister**

Native fish populations in arid regions throughout North America are threatened by numerous anthropogenic stressors, including the introduction of non-native fish species. This presentation highlights the Red Shiner, *Cyprinella lutrensis*, a small minnow native to the Mississippi River Basin that was identified as one of the greatest threats to native fish recovery in the Virgin River. The Virgin River is a tributary to the Colorado River with a unique species assemblage that includes the endangered Virgin River Chub, *Gila seminuda*, and Woundfin, *Plagopterus argentissimus*. By the 1980s, Red Shiner had colonized 86 miles of the Virgin River in Utah and decimated native fish populations. In response, the Utah Division of Wildlife Resources and its partners developed a six-phase eradication plan that aimed to completely remove Red Shiner from the Virgin River in systematic, step-wise, downstream phases. Each phase of the eradication plan involved five steps: 1) segmenting the river into manageable phases separated by fish barriers, 2) intensively monitoring Red Shiner distribution, 3) mapping all occupied and potential refuge habitat, 4) mechanically removing Red Shiner whenever possible, and 5) conducting chemical treatments using rotenone. Implementation of the eradication plan began in 1996, and the final phase was completed in 2021 when a chemical treatment was conducted in the Virgin River Gorge along the Utah-Arizona border. The final chemical treatment was a complex, interagency effort that successfully removed Red Shiner from the entire Virgin River in Utah and marked the culmination of nearly three decades of collaborative conservation. Post-treatment sampling indicates that native fishes have recolonized reaches cleared of Red Shiner. Nevertheless, ongoing management will be necessary to address other threats to native fishes and ensure that these enigmatic species persist in the Virgin River.

11:15-11:30: Virgin River Chub – **Kody Callister, Rick Fridell, Martin Schijf, & Melinda Bennion**

The Virgin River Chub, *Gila seminuda*, is an endangered fish species currently inhabiting about 16 miles of the Virgin River in Utah, USA. Factors threatening Virgin River Chub include

competition with non-native species – specifically Red Shiner, *Cyprinella lutrensis*, drought, elevated water temperature, decreased turbidity, alteration of natural flow regimes, and fluctuations in spawning and rearing habitat. Capture rates of Virgin River Chub age classes vary with sampling methodology; therefore, the Utah Division of Wildlife Resources (UDWR) has developed a monitoring program for adult Virgin River Chub to supplement previously established fish monitoring programs that effectively sample young chub. Since 2006, UDWR has conducted population monitoring for adult Virgin River Chub using hoop nets set overnight at five sampling stations between Pah Tempe Hot Springs and the Washington Fields Diversion on the Virgin River, with the addition of a station above Webb Hill barrier in 2014.

After a steep decline between 2006 and 2007, the number of Virgin River Chub captured during monitoring has varied, but the population appears to be stable. Years with high spring run-off tend to produce a lot of young chub and those young chub persist to maintain a stable population. Since 2016, chub monitoring results have increased to the highest ever catch in 2020, and then fell in 2021, but still represented the 4th highest catch since Virgin River Chub monitoring began.

11:30-11:45: Response of Endangered Species to Nonnative Eradication through Piscicide Application – **Skyler Hedden, Julie Carter, Matthew Rinker, Scott Rogers, & Kevin Guadalupe**

Nonnative fish are believed to be a major imperilment to native fish persistence and recovery and thus are a main focus of native fish conservation plans. But nonnative species management is complicated due to the difficulty of eradicating undesirable species while simultaneously having minimal effects on rare and endangered species that occupy similar areas and habitats. The most successful nonnative eradication tool in large riverine systems is piscicide application, but native species that occupy reaches in which problematic nonnative fish populations exists will also perish during treatment. We examined the response of native species following treatment of a 17-mile reach of the Virgin River, in Utah and Arizona to assess short term (less than 2 years) recolonization rates and if immediate benefits could be observed in the native fish community. In June 2021, over 200 gallons of rotenone solution was applied to the Virgin River to eradicate nonnative Red Shiners (*Cyprinella lutrensis*), resulting in complete mortality of all fish species, including some endangered species. Two months post treatment revealed large numbers of Virgin River Chub (*Gila seminuda*), an endangered species, had recolonized the upper reaches of the treatment area, while nonnative Red Shiners were still absent. Follow up sampling 14 months after the treatment showed a further increase in Virgin River Chub densities throughout the treated area with densities typically more than twice as high than downstream control reaches that have abundant Red Shiner populations. Our results highlight that nonnative eradication is possible with the use of piscicides even when endangered species are present, and that native fish populations have the ability to quickly recolonize treated reaches and appear be on a trajectory where robust native fish populations will exist.

11:45-12:00: Virgin River Riparian Habitat Restoration & Wildlife Conservation – **Christian Edwards & Rick Fridell**

The Virgin River originates from headwaters north and east of Zion National Park and travels southwest approximately 150 miles through Utah, Arizona, and Nevada before emptying into Lake Mead. In the St George area, the river meanders through a wide floodplain, which supports wetlands and associated riparian woodlands. In addition to providing water for urban

development and agriculture, the Virgin River supports hundreds of wildlife species including six native fish species and five aquatic and riparian conservation species. Three general actions are included in the preservation of the Virgin River 100-year floodplain: 1) land acquisition and floodplain protection, 2) species monitoring and recovery, and 3) habitat restoration. The Virgin River Program has worked in a collaborative effort to acquire and conserve hundreds of acres of the Virgin River floodplain below Zion National Park. The Utah Division of Wildlife Resources (UDWR) has conducted extensive monitoring of Virgin River fish species since the 1990s and annual monitoring of the Southwestern Willow Flycatcher, *Empidonax traillii extimus*, since early 2000s. UDWR monitoring efforts include population surveys, nest monitoring, cowbird control, and nest microhabitat/vegetation sampling. In addition to flycatcher habitat enhancement (e.g. selective tamarisk removal), general Virgin River floodplain restoration efforts have been conducted throughout the Virgin River Basin and include floodplain protection, riparian habitat maintenance, non-native removal (e.g. tamarisk, Russian Olive), and native revegetation.

12:00-13:30: **LUNCH**

THURSDAY AFTERNOON, NOVEMBER 17 – MAIN CONFERENCE ROOM

Student Awards Session – Moderator Sarah Seegert

*Student Presentations under consideration for **THE ROBERT RUSH & FRANCES HUBBS MILLER AWARD***

13:30-13:45: Advances on the genetic analysis of hybridization in the Yaqui catfish, *Ictalurus pricei* (Rutter, 1896) using mitochondrial & nuclear genes – **Alexsandre Gutierrez-Barragan, Alejandro Varela-Romero, Francisco Javier García-De León, Mariana Mateos, Carlos Alonso Ballesteros-Córdova, José Manuel Grijalva-Chon, & John Carlos Garza**

The Yaqui catfish *Ictalurus pricei* is an endangered species native to northwestern Mexico and southwestern United States, mainly due to hybridization with the exotic channel catfish *I. punctatus*. In the present work, we are analyzing the mitochondrial Cytb and COXI and the nuclear RAG1 and RAG2 genes for initial detection of hybridization with channel catfish in the Yaqui and Fuerte rivers. Hybridization has been detected in Arroyo Cajón Bonito and Río Tutuaca, in the Río Yaqui basin, and in Río Batopilas, in the Río Fuerte basin. Furthermore, possible genetic introgression was identified in the Río Tutuaca, indicating that the hybrids are fertile and interbreed with the parent species, which poses a greater threat to the integrity of the Yaqui catfish. Additionally, mitochondrial and nuclear genes of *Ictalurus* catfish from the Culiacán, Elota, Tunal and Conchos rivers were analyzed, but no evidence of hybridization was obtained. On the other hand, the analysis of whole genomes has begun to detect possible genetic introgression in samples of Yaqui catfish from the Arroyo Cajón Bonito, with the aim of creating a genetically pure reproductive stock.

*Student Presentations under consideration for **THE CARL L. HUBBS AWARD***

13:45-14:00: Conservation Genomics of Spikedace (*Meda fulgida*) – **Alex Cameron, Megan Osborne, & Thomas Turner**

Spikedace (*Meda fulgida*) is a small-bodied minnow endemic to the Gila River Basin (Arizona and New Mexico). Spikedace experienced geographic range contraction and declines in abundance in response to alterations of river flow and habitat, and coincident introduction of non-native species. To evaluate levels of genetic diversity, effective population size (Ne), and population structure we performed RAD-sequencing on 196 individuals from remaining wild populations and introduced populations. Genomic data consisted of 11,074 biallelic SNPs distributed across 25 chromosomes. Distinct lineages of Spikedace are present in Aravaipa Creek and the Upper Gila River. Aravaipa Creek retains the most genomic variation, suggesting long-term demographic stability compared with other wild populations. We found little evidence for natural selection contributing to the observed population structure. We recovered large effective population size estimates (Ne > 500) for wild populations in each lineage of Spikedace. However, there was considerable variability in Ne estimates among introduced populations, where two populations had low effective sizes (Ne ≤ 100), but a third exhibited Ne > 500. Overall, these data highlight how demographic stochasticity contributes to genetic population structure among desert fishes.

14:00-14:15: Effects of non-native crayfish on the structure & function of a stream food web in the lower Colorado River basin – **Gregor Hamilton, Thomas Turner, & Alesia Hallmark**

Non-native crayfish evoke concern because they are explosive breeders, occur at high densities, and eat, or compete with native species, including fishes. In the lower Colorado River basin, aquatic communities are thought to be especially vulnerable to food web alteration from crayfish invasion. In this talk, we present a stable isotope analysis of carbon, nitrogen, and hydrogen to describe and understand food web interactions between crayfish and their host community (including aquatic and riparian plants, invertebrates, and vertebrates) in the Tularosa River in Catron County, NM. Specifically, we asked: Are there isotopic niche differences based on the sex and age of the crayfish? Do crayfish act as indiscriminate omnivores or do they preferentially feed on specific resources? Does the isotopic niche of crayfish overlap with other functional groups and, if so, to what degree? We found that there are differences in resource use depending on the sex and size of individual crayfish. Collectively, the isotopic niche of crayfish differs depending on crayfish density, and crayfish resource use overlaps considerably with secondary invertebrate consumers. We also comment on the relationship of crayfish density and isotopic niche shifts of other community members, including fishes and other sensitive aquatic and riparian species.

14:15-14:30: Characterizing the fish assemblage in a reservoir forebay & identifying the potential for nonnative fish escapement into a desert river – **Barrett Friesen, Phaedra Budy, & Casey Pennock**

Native riverine fishes in arid regions face imperilment due to habitat fragmentation, water overallocation, and invasive species establishment. In the Colorado River basin, USA, these threats coalesce at Glen Canyon Dam, which impounds the Colorado River to create Lake Powell. Management agencies are concerned low water level in Lake Powell may increase the likelihood of nonnative fish entrainment through the dam, adversely affecting native fishes downstream in the Grand Canyon. Our ultimate goal in this study is to estimate the probability of nonnative fish entrainment and survival through Glen Canyon Dam to better inform invasion risk into the lower Colorado River. To this end, we are characterizing the fish community via sampling, conducting hydroacoustic surveys, and assessing fish movement and habitat use with acoustic telemetry near the dam. Preliminary data suggest entrainment risk varies by season and lake stratification. When the reservoir was cold (<10 °C) and well mixed in early March, the forebay was sparsely occupied by three species of nonnative coolwater fish (e.g., Walleye, *Sander vitreus*), which were restricted to the top 11 m of the mixed water column. Following reservoir warming (>20 °C surface temp.) and formation of the epilimnion, we collected an additional three species of nonnative warmwater fish (e.g., Smallmouth Bass, *Micropterus dolomieu*) down to 16 m depth. Gillnet catch per unit effort (CPUE) in the forebay increased by an order of magnitude between March and August, from 0.4 fish/net-night to 4.7 fish/net-night. Higher CPUE during the summer indicates greater fish abundance, movement, or likely both. As the dam penstocks are now drawing water from the epilimnion, increased nonnative fish abundance and activity in the forebay represents an increased entrainment risk. Our results will inform dam operations as managers seek to minimize the risk of entrainment while still meeting water delivery requirements and maintaining hydroelectric power generation.

14:30-14:45: Exploring Impacts of Lake Level Decline on a Critical Forage Species in a Large Terminal Desert Lake – **Sarah Barnes, Phaedra Budy, & Robert Al-Chokhachy**

In endorheic saline lakes in arid regions increasing drought conditions, water diversions for agriculture, and development cause significant lake level decline, potentially resulting in fish littoral habitat loss. Pyramid Lake, a large, deep, endorheic lake on Pyramid Lake Paiute Tribe land in Nevada, is home to Lahontan Cutthroat Trout, *Oncorhynchus clarkii henshawi*, a unique sub-species of cutthroat trout listed as Threatened under the Endangered Species Act. In Pyramid Lake *O. c. henshawi* success relies heavily on their primary forage species, the Tui Chub, *Siphateles bicolor*, a prolific, large-bodied, native minnow, whose abundance, according to long term gill net surveys, may be in decline. Here, we evaluated potential impacts of littoral habitat loss on *S. bicolor* spawning success. We combined *S. bicolor* abundance and habitat data, collected monthly at 9 sites from May to August, to investigate *S. bicolor* spawning adult and larval fish habitat selection. We sampled spawning fish with gill nets (5-30 m of depth), and larval fish with larval tows (5-60 m depth). We deployed temperature loggers at depths of 3, 15, and 30 m at each site for the duration of the sampling effort. We assessed substrate and vegetation from 5-30 m of depth using hydro acoustic transects conducted at every 500 m of shoreline, which we verified by SCUBA survey. Spawning adult catch-per-unit-effort (CPUE) was significantly higher at depths <10 m ($p < .001$) supporting our hypothesis that littoral habitat is important for *S. bicolor* spawning success. We observed greater than 5% composition of boulder and cobble substrates at 3 of the 9 sites surveyed using SCUBA, with 2 of the 3 sites coinciding with our highest observed spawning adult abundance, suggesting spawning adults may be selecting for the limited amount of boulder and cobble substrates within the littoral zone. In contrast to spawning adult abundance, we observed the highest larval fish density at the two most southern sites, a trend which may be driven by prevailing northerly winds. Integrating our results with lake bathymetry and elevation data would allow managers to better understand the relationship between lake elevation, littoral habitat, and *S. bicolor* and *O. c. henshawi* populations in Pyramid Lake. Mitigation strategies could include securing more water for Pyramid Lake and altering *O. c. henshawi* stocking regimes to not exceed *S. bicolor* carrying capacity.

14:45-15:00: From Bad to Worse: High Nonnative Densities & Monsoonal-Induced Habitat Deterioration in Backwater Nurseries may Explain the Recruitment Bottleneck of Imperiled Fishes in the San Juan River of NM, CO, & UT – **Blake Hansen, James Whitney, Amber Bell, Sasha Ewing, Michaela Fishback, Linden Jones, & Josh Holloway**

The Razorback Sucker, *Xyrauchen texanus* and Colorado Pikeminnow, *Ptychocheilus lucius* are federally-endangered species occurring in the San Juan River of NM, CO, and UT. These species have shown little natural recruitment in this system, with a lack of high-quality nursery habitats being one potential explanation for this phenomenon. The young-of-year of both species prefer backwaters, including those that form in secondary channels or in association with islands. However, it is unknown how factors that could limit imperiled fish recruitment, such as nonnative densities, resource availability, and physicochemical features, differ between secondary channel and island backwaters. Furthermore, how these environmental features vary during the critical post-spawning window of the July-September monsoon season within and across years is also poorly understood. As such, we compared nonnative and native densities, chlorophyll-a concentrations, turbidity, percent silt substrate, and mean depth between the two backwater types across 20 sites (i.e., 10 of each type) sampled on five occasions each in 2021

and 2022. We found that nonnatives attained higher densities in secondary channel than island backwaters, and in both backwater types they had much higher densities than natives. Furthermore, both backwater types had low chlorophyll-a concentrations that likely resulted from high turbidity and coverage of unstable silt substrate. Furthermore, silt coverage increased throughout the monsoon season, which resulted in habitat aggradation and declining depth. Lastly, flow events that were likely detrimental to recruitment occurred in both study years, including a fish kill following a monsoonal flow pulse in 2021, and a flow reversal in 2022 characterized by extreme low flows that caused backwater drying during July 09-25 (mean discharge = 387 cubic feet/second) followed by high flows that caused backwater flushing during July 26 – August 08 (mean discharge = 1,985 cubic feet/second). Our results suggested that both backwater types had low nursery quality that became even poorer throughout the monsoon season, which may explain the recruitment bottleneck. Identifying strategies for improving backwater nursery quality (e.g., environmental flows management) will be paramount in helping to alleviate the recruitment bottleneck of imperiled Razorback Sucker and Colorado Pikeminnow in the San Juan River, thus aiding in their recovery.

15:00-15:15: **BREAK**

Student Awards Session – Moderator Megan Osborne

Student Presentations under consideration for ***THE CARL L. HUBBS AWARD*** *(CONTINUED)*

15:15-15:30: Hydroperiod shapes aquatic invertebrate communities of Sonoran Desert rock pools – **Susan Washko & Michael Bogan**

Hydroperiod is a strong environmental filter for aquatic life, selecting invertebrates with life histories that match the timing and duration of inundation. However, adaptations and traits may allow some taxa to survive shorter hydroperiods. Rock pools, such as those in the Sonoran Desert, are ideal study systems to test whether aquatic invertebrate communities residing in pools of different hydroperiods are different in terms of community composition and trait composition. We monitored ten rock pools in Organ Pipe Cactus National Monument, Arizona, USA, tracking the hydroperiod and sampling the aquatic invertebrates. We found that pools with shorter hydroperiods differed in both community composition and trait composition from pools with longer hydroperiods. Pools with longer hydroperiods tended to have higher species richness and indicator taxa that were mostly active dispersers, while pools with shorter hydroperiods tended to have lower species richness and indicator taxa that were desiccation-tolerant and had short life cycles. Shorter hydroperiod pools contained higher proportions of aerial passive dispersers, and consequently, lower proportions of active dispersers. Short-lived pools also had higher proportions of taxa exhibiting diapause, though diapause was common in both long and short hydroperiod pools. These results demonstrate the significance of hydroperiod as an environmental filter, giving insight into what aquatic invertebrate communities in rock pools could look like as climate change continues to alter hydroregimes.

15:30-15:45: The Toad & the Crayfish: Arizona Toad & Non-native Species Occupancy & Interactions in Streams of Arizona – **Brett Montgomery & Heather Bateman**

The Arizona Toad (*Anaxyrus microscaphus*) is a unique southwestern toad because they primarily breed in streams of Arizona, New Mexico, Utah, and Nevada. Arizona Toad is a species of conservation concern throughout their range due to hybridization, flow regime changes, and habitat loss. Invasive aquatic species, such as crayfish, are suspected to impact Arizona Toads, but this risk has not been evaluated. The non-native Northern Crayfish (*Orconectes virilis*), which co-occurs with the toad in the Mogollon Rim, are opportunistic omnivores implicated in the declines of other native aquatic species. We used visual encounter toad survey data from 2021 and 2022, and crayfish occurrence records, to determine if there are any interactions between the two species. We applied three occupancy modeling approaches, single-species, two-species, and species interaction models, focused on streams throughout the range of the Arizona toad in Arizona. Using our first season of data, we found Arizona Toad site occupancy probability was 0.165 (SE = 0.03) and detection probability when present was 0.734 (SE = 0.06) with the single-species models. The top two-species occupancy model showed toad site occupancy probability in the presence of Northern Crayfish was 1.0 (SE < 0.01), with the species interaction factor of 1.0 (SE = 0), indicating species independence. During the second season, Arizona Toad site occupancy probability was 0.221 (SE = 0.057) and detection probability when present was 0.841 (SE = 0.087) in the single-species models. The top two-species occupancy model produced the same results as the first season, showing species independence. Overall, our single season results found low toad occupancy, but high detection, as well as significant overlap with crayfish. Understanding toad-crayfish co-occurrences and interactions in areas dominated by crayfish is critical for risk assessment and this work provides a framework to further address these issues.

15:45-16:00: Walking a Fine Line: Miniature Distance Sampling Reveals Greater Abundance of Imperiled Conchos Pupfish in Marginal Habitats – **Lindsey Elkins, Joshuah Perkin, Matthew Acre, Megan Bean, Sarah Robertson, & Ryan Smith**

Desert spring systems of the American southwest hold high local fish endemism and are ranked among the most threatened ecosystems in the world. The prioritization of conservation resources to protect species living within these arid landscapes requires knowledge of species abundance and distribution, but traditional survey methodologies can be challenging to apply in shallow ecosystems occupied by diminutive species. For example, the plight of desert-dwelling Conchos pupfish (*Cyprinodon eximius*) is representative of freshwater fishes the world over, including population extirpations caused by human poisoning of streams and reservoir construction, to the extent that the species was once considered extinct in the USA. We developed a novel application of miniature distance sampling to investigate spatiotemporal patterns in Conchos pupfish abundance and coupled this approach with species distribution modelling to guide conservation actions. Our multiscale approach included surveying abundances within 5-m transects (101-m), nested within three reaches (102-m) of the Devils River, USA (104-m), combined with species distribution modelling within stream segments (103-m) across the range of the species within the Río Grande basin, MEX and USA (105-m). Modelling revealed Conchos pupfish range correlated with low December precipitation and climate moisture index, but high herbaceous land cover and potential evapotranspiration rates. Within the Devils River, abundance was greatest, and most volatile, at the reach that experienced the greatest amount of drying, and among transects with minimal velocities and

shallow depths. These results collectively highlight Conchos pupfish use of habitats on the margin between aquatic and terrestrial realms, where slight reductions in water availability could strongly affect the species. Our transferable framework provides conservation guidance by identifying (1) transect locations where fine scale protected areas might be delineated, (2) reaches where high abundances could be protected or used for repatriation, and (3) stream segments where future surveys might be conducted.

16:00-16:15: Wood you believe it? Experimental Nonnative Wood Addition Enhances In-Stream Habitat for Native Desert Fishes – **Benjamin Miller, Casey Pennock, & Phaedra Budy**

Habitat loss and degradation is a major worldwide driver of freshwater biodiversity decline. Habitat simplification is contributing to the decline of native fishes throughout the Colorado River basin; in the San Juan River (SJR, a major tributary of the Colorado River), flow regulation, overallocation of water, and establishment of nonnative riparian vegetation (primarily Russian olive *Elaeagnus angustifolias*) have all contributed to broad scale habitat simplification. To inform managers of the potential for native fish habitat enhancement using abundant nonnative woody vegetation, we designed an experiment to test the efficacy of using cut Russian olive to enhance in-stream habitat to benefit native fishes. To achieve this goal, we constructed 120 woody structures consisting of existing Russian olive at 12 sites within the main channel of the SJR in fall 2021. To evaluate fish use and potential habitat changes, we subsequently sampled fishes, macroinvertebrates, habitat (depth, velocity, and dominant substrate size), and deployed portable PIT tag antennas at treatment and paired reference reaches that did not receive wood treatments. During the first-year of sampling, we captured a total of 1,216 fishes in treatment reaches (13% native) and 1,149 fishes in reference reaches (9% native species). Native fish and macroinvertebrate densities were higher on average (44% and 160%, respectively) in treatment reaches than in reference reaches. Total unique fishes detected by PIT antennas was higher in reference reaches than in treatment reaches for both native and nonnative species (80% and 71%, respectively). Habitat composition (depth, velocity, and dominant substrate size) did not differ between reference (means, 0.34 m, 0.26 m/s, 38.40 mm, respectively) and treatment (0.34 m, 0.28 m/s, 51.9 mm, respectively) reaches; however, at the scale of woody structures, depth, velocity, and dominant substrate size means were 0.17 m, 0.09 m/s, and 3.61 mm, respectively. High sedimentation rates facilitated the formation of large (~ 0.5 m tall) sand bars behind most structures, which contributed to increases in habitat complexity, but also stranded structures in some instances. Beaver appeared to feed on Russian olive at multiple sites, and in some cases, this led to the dismantling of woody structures. Presently, in year-two of the project, we adapted our experimental design in attempt to mitigate the effects of beaver activity and stranding of structures by constructing fewer, larger woody structures further from shore in treatment reaches. Our year-1 results suggest that addition of nonnative woody structures is an effective management action for increasing habitat complexity and enhancing native fish habitat at the local scale. Ultimately, this experiment aims to better inform managers of the potential for native fish habitat enhancement by exploiting an existing and abundant nonnative vegetation resource.

16:15-16:30: Exploring movement patterns of an endangered minnow in a fragmented desert river – **Martinique Chavez, Phaedra Budy & Casey Pennock**

Most large rivers in North America are fragmented by dams that modify natural flow regimes, reduce connectivity, and imperil freshwater fishes by restricting movement among patchily distributed resources. Coincident with widespread river fragmentation are declines of numerous endemic desert fishes. The Rio Grande Silvery Minnow (*Hybognathus amarus*, RGSM) has experienced a 95% reduction in its historical range. The overall goal of this study is to better understand the movement ecology of RGSM, and identify possible drivers of movement patterns. We used Passive Integrated Transponder (PIT) tags in stocked RGSM with stationary and mobile PIT-tag antenna systems to detect and track movement patterns across time and space. We detected 16,036 PIT-tagged RGSM of the 36,644 released, an extremely high resight rate (43%). The mean distance moved by PIT-tagged RGSM was 10.6 km, and the maximum distance moved was 142.9 km. Tag movements were generally directed downstream, but 26% of movements were directed upstream. We observed a bimodal distribution of home range sizes with a mean home range of 2.4 km and a maximum home range of 78.2 km. The strongest predictor variables for an individual having a larger home range size were number of days at large (R2 = 0.22) and number of days above 1,000 cfs (R2 = 0.19), indicating RGSM movement might be associated with higher flows. Surprisingly, a total of 104 individuals passed upstream through the San Acacia Dam. Our data suggest RGSM are highly mobile, with the predilection to make long-distance movements both upstream (to the extent possible) and downstream. Direct evidence of RGSM movement patterns may provide crucial insights that could help target recovery efforts and highlight the need to restore connectivity through the removal or redesign of diversion dams to include fishways. A greater understanding of how river fragmentation impacts the movement patterns of imperiled fishes can help guide and better inform the management of desert riverscapes to ultimately achieve self-sustaining populations of native fishes.

16:30-18:00: **Poster Session & social with snacks provided – main conference room (next page):**

18:30-20:30: **Student Networking session**

THURSDAY AFTERNOON, NOVEMBER 17

16:30-18:00 Poster Session & social with snacks provided – main conference room

*Student Posters under consideration for **THE POSTER AWARD***

1. Population genetics of sand shiner (*Notropis stramineus*) across the Great Plains - **Huachan Liang, Chloe McGuan, Guilherme Caeiro-Dias, & Megan Osborne**

   The sand shiner, *Notropis stramineus*, is a small body fish that inhabits a variety of environments including sandy-bottomed streams and rivers. Sand shiners are distributed across the Great Plains to the eastern United States. On the basis of morphology two subspecies are recognized. However, genetic analysis using microsatellites and a mitochondrial gene identified five clades within sand shiner suggesting at least five cryptic species that were not associated with previously described subspecies. Here we used microsatellite data from 7 loci to investigate the distribution of genetic diversity within three of these groups (clades A, M and R) represented by 29 localities and 866 samples. Preliminary analysis showed that all populations sampled encompass relatively high levels of genetic diversity with the highest gene diversity in the most widely distributed M clade (Upper Mississippi River), followed by the A clade (Arkansas, Canadian) and the R clade (Red River). Allelic diversity was lowest in the Red River group. We found that a significant proportion of genetic variance was explained by differences between previously identified genetic clades (A, M and R) and between localities within clades. Results provide insights into the evolutionary history of the group.

2. Endangered & in danger: a test of acquired predator recognition of novel predators by pupfish *Cyprinodon nevadensis shoshone* – **Molly Johnson, Kathryn Hanson, Craig Stockwell, & Brian Wisenden**

   Small fishes generally do not have innate predator recognition. In fact, predator recognition is acquired by associative learning when conspecific chemical alarm cues, which are typically released when the skin cells are ruptured during a predator attack, are paired with another novel stimulus such as the appearance or odor of the predator. Alarm cue alerts nearby prey to the presence of an actively foraging predator, evoking antipredator responses such as reduction in activity, movement out of the water column and seeking shelter. Work on minnows has shown that a single pairing of alarm cues and a novel predator odor confers near-permanent avoidance of the novel odor in future encounters. Recent work in our lab showed that pupfish Cyprinodon nevadensis shoshone and *C. n. amargosae* exhibit antipredator responses to conspecific skin extract. Here, we test if *C. n. shoshone* can be trained to recognize and avoid the odor of a novel predator, largemouth bass, *Micropterus salm*oides, by pairing bass odor (earthworm diet) with pupfish skin extract, or using odor of bass that were maintained on a diet of pupfish. These findings will provide insight into the capacity of Shoshone pupfish to adapt to the presence of novel invasive predators in an otherwise isolated desert system.

3. Aquatic Invertebrate Monitoring in Saguaro National Park: Biodiversity & Citizen Science – **Maya Tainatongo**

   The tinajas of Saguaro National Park are unique aquatic ecosystems that provide habitat for many aquatic species throughout the dry seasons in the Sonoran Desert. However, as climate change continues to impact drought and rain periods across the park, these tinaja ecosystems will be irreversibly impacted. Decreasing rainfall leads to less water recharge of the tinajas and

increased temperatures means higher tinaja evaporation rates. We expect this to affect aquatic habitats in terms of their hydroperiods, or length of inundation, which is the limiting factor for aquatic invertebrate colonization. The Saguaro National Park region has already been affected by higher average temperatures and reduced rainfall. Through this project, our goal is to investigate the hydrology parameters that have the greatest impact on aquatic invertebrate diversity within each pool. There has been very little documented research into the aquatic invertebrate populations in the tinajas at Saguaro National Park, specifically within the Wildhorse drainage. Aquatic insects are vital as they provide food to many of the species that inhabit and frequent the pools such as frogs and birds.

General Posters

4. Lower Colorado River Area Report – **Ron Rogers**

   The lower Colorado River Basin encompasses an area that spans from Lee's Ferry, Arizona, approximately 15 river miles below Glen Canyon Dam (Lake Powell), to the Gulf of California (Sea of Cortez), Mexico. Historically, the dynamic nature of river would have meandered across large flood plains, creating isolated pools, oxbow lakes, and backwater habitats, that were broken in small areas by when not bound by narrow canyons and high gradient reaches. This ecosystem was home to numerous species of fish, reptiles, plants, and invertebrates. However, in less than 100 years, a system of dams, diversions, levees, and canals has left this region as one of the most managed rivers in the world. Many scientists are currently working within the basin to better understand, conserve, and enhance endangered, threatened, and native fish populations. This report highlights some of the research, monitoring, and recovery efforts for fishes within the lower Colorado River Basin.

5. Parasites of cypriniform fishes of the Santa Clara River – **Max Murray**

   Freshwater fishes in the southwestern United States live in some of the most highly modified habitats in the country. As a result, the relatively small number of native fish species have been impacted in many ways including the introduction of nonnative fishes and their parasites. 35 *Catostomus santaane* (Santa Ana sucker), 61 *Catostomus santaanae* x *Catostomus fumeiventris* F2 hybrids, 18 *Pimephales promelas* (fathead minnow), and 214 *Gila orcutti* (arroyo chub) were collected and necropsied in the summers of 2017 and 2018. Ten species of macroparasites were collected from these fishes including six native and four nonnative parasites. The most abundant species of native parasite was *Rhadbochona* sp. while the most abundant nonnative parasite was *Lernaea cyprinacae* (anchor worm). The prevalence of *Rhadbochona* sp. was highest in *G. orcutti* (69%) and lowest in *C. santaanae* (5%). The prevalence of *L. cyprinacae* is highest in *G. orcutti* (29%) and lowest in *P. promelas* (5%).

6. Grapevine Creek: Creating Gila Trout Angling Opportunities from Eyed Egg Stockings – **Emily Keister & Zach Beard**

   Grapevine Creek is a tributary to Big Bug Creek in the Aqua Fria River watershed located in the Bradshaw Mountains near Mayer, Arizona. Gila Trout *Oncorhynchus gilae* were first stocked into Grapevine Creek by the Arizona Game and Fish Department in 2009 and persisted there until 2017, when the Goodwin Fire, which burned approximately 28,516 acres in the Bradshaw Mountains, eliminated the population. In an attempt to re-establish a Gila Trout population in

Grapevine Creek, 19,000 eyed Gila Trout eggs were stocked into Grapevine Creek in April 2019. Visual surveys in May and August of that year indicated that the egg stocking was a success with 348 Gila Trout observed during a visual survey in May 2020. Additional eyed egg stockings of 6,000 eyed eggs and 2,000 eyed eggs occurred in April 2020 and March 2021. An initial population estimate in March of 2021 estimated the total population of Gila Trout within the 1.2km of perennial stream to be 336 individuals with an 80% confidence interval of (142 531). With the success of the 2019 stocking and large numbers of Gila Trout observed in Grapevine Creek, the Arizona Game and Fish Commission approved a proposal to open Grapevine Creek to seasonal catch and release angling beginning in 2021. From the available angling data, 53 Gila Trout have been caught by 13 anglers at Grapevine Creek, accounting for 44 hours of angling activity, with all but two anglers being 'very satisfied' with the catch rates for Gila Trout. Grapevine Creek has been a tremendous success for the recovery of Gila Trout by restoring a new population, and by providing new opportunities for angling.

7. Evaluating the Relationship between Flow & Smallmouth Bass Abundance, Growth & Diet on the White River, Utah – **Justin Furby, Matt Breen & Casey Pennock**

   Establishment and expansion of invasive Smallmouth Bass, *Micropterus dolomieu*, in the upper Colorado River basin coincides with declining native fish populations. An enhanced understanding of Smallmouth Bass ecology in invaded rivers is crucial to inform management efforts directed at reducing bass abundance to aid recovery of native fishes. The White River in Utah maintains a relatively natural flow regime in comparison to other tributaries to the middle Green River. Our objective is to quantify relationships between flow and Smallmouth Bass catch-per-unit-effort, first-year growth, and diet in the White River, Utah. To achieve this objective, we will use a multifaceted approach including active sampling via raft electrofishing, growth estimation using sagittal otoliths, and stomach content analysis. Catch rates of Smallmouth Bass in a 76-kilometer river reach (UT state line to Enron) of the White River varied over time, and increased between 2012 (0.49 bass/hr) and 2021 (23.53 bass/hr). However, catch rates in 2022 (3.09 bass/hr), a relatively low-flow year, were 86% lower than those in 2021. Juvenile fish consistently make up the majority of fish captured in this reach (2012-2022: 73-98% of individuals <200 mm TL). In June 2022, we preserved 58 fish for age, growth, and diet analysis. Analysis of otoliths confirmed 67% of captured fish were age-1 (mean TL = 122 mm, range= 99 mm-144 mm), and the oldest fish analyzed were age-4 (range = 308 mm-368 mm). Aquatic macroinvertebrates were the most frequently encountered prey group in bass stomachs and were found in 63% of fish (17% of total biomass). Bass demonstrated moderate rates of piscivory as cyprinids were encountered in 31% of stomachs (62% total biomass). Crayfish were the least encountered prey item, found in 6% of stomachs (21% biomass). Preliminary results suggest a potential negative correlation ($r = -0.59$, $P < 0.001$, $n = 75$) between mean daily spring flow (May-June) and first-year growth. We plan to continue collecting Smallmouth Bass in 2023 to bolster our sample size, and potentially include fish captured in reaches closer to Taylor Draw Dam, Colorado, where adult fish are more prevalent. Ultimately, this study will inform management of nonnative Smallmouth Bass by providing a more complete understanding of lotic Smallmouth Bass ecology in the Upper Colorado River Basin.

8. Use of the Gila Topminnow, *Poeciliopsis occidentalis*, for vector control – **Elizabeth Grube & Brian Hickerson**

   Standing waters are prime breeding habitat for mosquitoes, a vector for diseases, that can pose a serious public health threat to the community. Due to their reputation as mosquito-control agents, the Western mosquitofish, *Gambusia affinis*, have been stocked around the world. to control larval mosquitos. Mosquitofish are recognized as a highly invasive and detrimental aquatic nuisance species that are a direct threat to topminnow and other native aquatic species throughout Arizona. The use of Gila Topminnow, *Poeciliopsis occidentalis*, as a means of vector control directly eliminates the need to use Mosquitofish. Arizona Game and Fish Department has been partnering with Pima and Pinal County and private ranches and guest ranches in southern Arizona to use Gila Topminnow as vector control at specific, isolated and unconnected waters. The success of these programs has also encouraged private landowners to enroll in the Topminnow and Pupfish Safe Harbor Agreement to replace mosquitofish in their private waters.

9. Using a genetic approach to identify undetermined fish to species, with an example from Central Arizona - **Matthew Mayer, Scott Bonar, Melanie Culver, & Kaitlyn Gahl**

   Identification of small fish can be difficult if not impossible in the field. Genetic Identification can provide a solution; however, there are techniques that need to be followed to identify the organism. We used mitochondrial genetics to confirm the species identification of small cyprinids found in remote wilderness streams in the Coconino National Forest in Central Arizona. As part of a project to help protect and develop the in-stream water rights for these streams; we identified the fishes in these creeks and their habitat use. We found a few sites in the upper portions of the two streams and one of their tributaries that were occupied by juvenile cyprinids that we could not identify based off appearance and morphology. We were aware that assuming their identity would be risky and planning a return trip would be difficult, so we collected fish from each stream for a total of 27 specimens all of which we stored in alcohol. We returned them to the University of Arizona and isolated the DNA of the fish using a Qiagen kit and identified them to species using a portion of the Mitochondrial Cytochrome B gene. To do that we Sanger sequenced all the individual fish's portions of the Cytochrome B gene after running a Polymerase Chain Reaction to amplify the sequences. Then after sequencing we cleaned the sequences and used the National Library of Medicines, National Institute of Biotechnology Resources, Nucleotide Blast Query option to determine the specific identity of the fish. By going through this process, we learned that genetic identification is straightforward and can be done easily by people with no prior experience in genetics. Using this process, we were able to identify fish that otherwise would not have been Identifiable and provide this knowledge to the managers of these streams to improve future decisions and conservation efforts.

10. Green Sunfish: Aquatic Gremlins of the Southwest – **Eric Frye & David Ward**

    The 1980's Steven Spielberg movie, "Gremlins", featured a small invasive creature brought home as a pet, which subsequently reproduces, terrorizes the town, and eats its inhabitants. Green sunfish (*Lepomis cyanellus*) in a similar fashion do not reach large body sizes, do not have large teeth or noticeably large mouths, and are commonly transported into new locations by unsuspecting adults and children. They quickly reproduce and aggressively prey on other fishes, eliminating recruitment of southwestern native fishes in waters where they coexist. Despite

their small size, and relatively benign appearance, green sunfish arguably do more damage to native fish populations than any other invasive fish in the desert southwest. When flood events occur, they spread rapidly across the landscape. In 2021, at Palmeroy Tanks, near Williams, Arizona, we recorded downstream movement of green sunfish before and after monsoon flooding. Thousands of individuals exited an existing pond and moved over 10 kilometers downstream during a single rain event to colonize a series of previously dry ponds. In the laboratory, we evaluated the predation potential of green sunfish in 24-hour trials and compared their predation ability to other introduced predatory fishes found in the Colorado River Basin. Green sunfish commonly consume juvenile chub at a larger proportion of their maximum anatomical gape (50%) than even smallmouth bass. Their aggressive predatory behavior at extremely small sizes allows them to access larval native fish populations in shallow, near-shore environments that are not available to other predators. Green sunfish then continue to prey upon native fishes until the prey outgrow the maximum anatomical gape of about 35 mm for adults. The high propensity of green sunfish to be moved by humans and then dispersed during flood events, their ability to survive and reproduce under a wide range of environmental conditions, and their aggressive predatory behavior makes them a significant threat to native fish conservation in the desert southwest.

11. Defending Crystal Spring: eradicating the green sunfish (*Lepomis cyanellus*) from Ash Meadows National Wildlife Refuge – **Emma Priger, Michael Reeves, & Leah Simantel**

    Ash Meadows National Wildlife Refuge (AMNWR, Refuge) in southeastern Nevada is the largest remaining oasis in the Mojave Desert, supporting at least 50 springs and seeps within approximately 24,000 acres. These springs and seeps support the second highest level of endemism in North America, with 26 known rare and endemic species, including 3 endangered, endemic fishes. In January of 2021, nonnative green sunfish (*Lepomis cyanellus*) were found in the Crystal Spring system, the largest spring on the Refuge, presumably having invaded from a downstream reservoir after the failure of a fish barrier. Crystal Spring is a popular visitor destination and important habitat for several endemic aquatic species including the Ash Meadows Amargosa pupfish (*Cyprinodon nevadensis mionectes*) and several unique invertebrates including the Crystal Spring springsnail (*Pyrgulopsis crystalis*), making it a priority for aquatic invasive species control. A green sunfish control effort was initiated in February of 2021 to reduce competition and predation pressures on these endemic species, focusing on mechanical control methods over chemical methods to limit non-target mortality. The control effort was designed within an adaptive management framework, incorporating effectiveness monitoring in the form of catch and effort statistics for individual gears and system-wide monthly visual snorkel surveys. Results are being used to reallocate effort among gears and locations to maximize catch. Rod and reel angling, unattended angling (i.e., yo-yos), spearfishing, and hoop nets have been used, yielding varied results. Hoop nets have yielded the largest catch across all methods (n=178). Rod and reel angling (n=12) and spearfishing (n=12) have also been successful, particularly in specific habitats such as the spring head. Hoop net catch rates and visual snorkel surveys have both been encouraging, with the number of sunfish detected declining over time, presumably in response to declining abundance. The integrity of downstream fish barriers is also being monitored as a hedge against reinvasion using both visual inspections and a stream-wide PIT tag reader to detect green sunfish previously tagged downstream (n=21). There have been no detections of tagged fish above existing fish barriers, verifying their integrity to date. Refuge staff continue to adapt control efforts with the goal of

complete green sunfish eradication prior to 2024 when a large-scale restoration of the lower Crystal Spring outflow is scheduled to commence.

12. Idiosyncratic anti-predator responses of two desert fishes to invertebrate predation risk - **Bridger Scraper, Sekhar M.A., Shawn Goodchild, Craig Stockwell, & Brian Wisenden**

    The evolutionary naiveté hypothesis has been invoked to explain the vulnerability of isolated desert fishes to non-native predators, but until recently the behavioral mechanisms have not been explored. Recent work showed that Moapa White River springfish, *Crenichthys baileyi moapae* responded to conspecific chemical alarm cues, whereas Pahrump poolfish, *Empetrichthys latos* did not respond to alarm cues. These differential responses call for a better understanding of anti-predator behavior toward non-native predators as well as native predators. Nymphs of various dragonflies have been reported to prey on the larvae of aquatic vertebrates, but little work has explored dragonfly predation on the larvae of desert fishes. Here, we evaluate poolfish and springfish responses to a native odonate predator, the green darner, *Anax junius*, because it co-occurs with various desert fishes. We conducted mesocosm experiments and time to capture trials to explore population-level and individual-level responses to nymphs of the green darner. In experimental mesocosms, dragonfly nymphs reduced the number of poolfish larvae produced, whereas dragonfly nymphs had no negative effect on the number of springfish larvae produced. Staged time-to-capture interactions between dragonfly larvae and juvenile fish show that springfish are highly vulnerable to dragonfly predators. Time to capture for poolfish will also be reported. Finally, we will present data on larval behavioral responses to alarm cue for both springfish and poolfish that were hatched either in the presence or absence of dragonfly nymphs. These findings suggest that dragonflies may impact desert fish species, but individual-level and population-level responses do not directly correspond. These studies will provide insights on how evolutionary history with native predators may facilitate or constrain anti-predator responses to non-native predators.

13. Assessment of Headwater Catfish (*Ictalurus lupus*) genetics in Texas & New Mexico – **Megan Bean, Dijar Lutz-Carrillo, Joanna Hatt, Brian Ferguson, Joshuah Perkin, & Stephanie Parker**

    Putative Headwater Catfish (*Ictalurus lupus*) were collected from drainages in Texas and New Mexico and sequenced at the Cytochrome b gene (Cyt b) to determine taxonomic status. Populations were also assessed for hybridization with Channel Catfish. Catfish samples collected from the Gila River and Beaver Creek in New Mexico produced two haplotypes among all samples - one associated with Headwater Catfish and one associated with Channel Catfish. Assessment of the Balmorhea State Park population in Texas revealed 20% of samples were hybrids of Headwater Catfish and Channel Catfish and all hybrids took the form of potential F1s. Population assessment will also be presented for other Texas populations.

14. Monitoring Comanche Springs Pupfish, Pecos Gambusia, & Leon Springs Pupfish populations in West Texas – **Megan Bean, Ryan Smith, & Dijar Lutz-Carrillo**

    Initial genetic assessments and population monitoring has been conducted for several endangered species in several locations including Comanche Springs Pupfish, Pecos Gambusia, and Leon Springs Pupfish.

15. The Development & Feasibility of Using Camera Traps to Monitor Pupfish Populations – **Megan Bean, Preston Bean, Dominik Chilleri, Robert Mollenhauer, Joshuah Perkin, & Matthew Acre**

    No abstract.

16. Nevada Area Report, 2022 – **Eric Miskow, Kevin Guadalupe, Dan Dauwalter, & Chris Crookshanks**

    Nevada waters contain 16 endangered and 6 threatened fish species and numerous undescribed at-risk fish taxa. This report contains a summary, overview, and status of a select few of Nevada's desert -fishes, as well as current research and management projects initiated in the state over the past year.

17. Using telemetry to track the movements of a federally endangered desert sucker – **Justin Handtke, Brandon Albrecht, Ron Rogers, Mark McKinstry, & Kerri Pedersen**

    Advances in telemetry technology has provided insight into the movements of imperiled freshwater fish species, such as the Razorback Sucker in the Colorado River Basin. Due to their large-scale movements across both lentic and lotic systems, telemetry-based movement studies are used to better understand these large-scale patterns. Both active and passive tracking techniques have been used to better understand Razorback Sucker habitat use throughout Lake Mead and the Colorado River flowing into to the Grand Canyon, since 2014. During this time, large-scale movements between these two systems have been documented, despite the formation of natural barriers, such as Pearce Ferry Rapid, which appears act as a barrier to movement for both native and nonnative fishes. Continued telemetry and ongoing studies will aid in a better understanding of the near annual wild recruitment of Razorback Sucker in Lake Mead and Colorado River.

18. Evaluating water temperature & stream flow in the lower Virgin River, near Mesquite, Nevada, 2019-2021 – **Katherine Earp**

    The lower Virgin River is a shallow river that flows from southwestern Utah to Lake Mead in Nevada and Arizona. The Virgin River hosts several native fish species, including two endangered fish, woundfin (*Plagopterus argentissimus*) and Virgin River chub (*Gila robusta seminuda*), all which have seen reductions in population sizes since 1970. Reduced river flow (especially during summer low flow conditions) often results in higher stream temperatures, which can increase mortality, reduce breeding, limit population connectivity, and favor non-native species. This study investigated changes in water temperature and river discharge to provide pertinent data that directly impacts native fish species. The three-year monitoring project collected continuous temperature and discrete discharge measurements at 15 sites from 2019-2021. Preliminary results indicate that maximum summer water temperatures at many sites reach 34-36 degrees Celsius, several degrees above the published thermal maximum of 31 degrees Celsius for the survival of the endangered fish. During the study period, temperature was independent of flow at baseflow conditions, but temperature increased with reduced flows.

19. Cutthroat Trout chromosome-level genome assembly – **R. Paul Evans, Kevin Rogers, Dennis Shiozawa**

    A chromosome-level genome assembly for *Oncorhynchus clarkii stomias* (Greenback Cutthroat Trout) was produced using Illumina, Pacific Biosciences, Hi-C, and transcriptome data from a Bear Creek, Colorado population male. The assembly spans 2.3 Gb with a contig N50 of 11.2 Mb and 97% of the genome assigned to 33 chromosomes. The observed high rate of duplication for eukaryotic universal single-copy orthologs (BUSCO), 46%, is consistent with the autotetraploid origin of the *Oncorhynchus* genome. A reference genome for Cutthroat Trout allows for ready implementation of next generation sequencing based, conservation directed analyses of individuals and populations in this enigmatic species.

FRIDAY MORNING, NOVEMBER 18 – MAIN CONFERENCE ROOM

07:30-08:30: Presentation loading in person (if not emailed ahead of time)

08:30-08:45: Welcome – Kevin Wilson

General Session – Moderator Joanna Hatt

08:45-09:00: Predicting an invasion: Smallmouth bass near-term risk below Glen Canyon Dam – **Drew Eppehimer, Charles Yackulic, Lindsey Bruckerhoff, Jian Wang, Kirk Young, Kevin Bestgen, & John Schmidt**

Invasive fishes are a primary cause of declines in native fish species throughout the United States including the Colorado River Basin. Although dams and reservoirs have dramatically altered the natural ecosystems of regulated rivers, they also serve as barriers to the movement of invasive fishes. Warmwater invasive fishes, such as the smallmouth bass (*Micropterus dolomieu*), have invaded much of the Upper Colorado River Basin and are abundant in Lake Powell. Historically, Glen Canyon Dam limited propagule pressure of smallmouth bass from the Upper Basin and created thermally unfavorable conditions downriver. Currently, use and management of the Colorado River is facing a paradigm shift due to long-term drought that has decreased storage in the river's reservoirs creating great uncertainty about critical water supply and limiting efforts to manage the river's natural resources. Lower elevations in Lake Powell are expected to increase rates of fish passage through the dam and create thermally suitable conditions in Lees Ferry for smallmouth bass. To quantify the risk of smallmouth bass establishment downstream from Glen Canyon Dam, we developed predictive entrainment and thermal suitability models. These models are relatively simple tools based primarily on Lake Powell elevation, which pairs the depth of dam's intakes with fish depth distributions and thermal profiles. Our model results show that risk of establishment increases with decreasing elevation, and downriver risk increases over time as individuals accumulate at rates that outpace annual mortality. Our models also illustrate that under current and projected elevations, temperatures in Lees Ferry are and will be suitable for smallmouth bass reproduction. Water storage decisions that maintain or increase Lake Powell elevation reduce the potential for smallmouth bass establishment in the Grand Canyon in the short term. Potential responses to an invasion also include deep water, selective withdrawal dam operations to cool the river.

09:00-09:15: Monitoring invasive Northern Pike *Esox lucius* in Utah Lake – **Ben Wiley, Kurtis Shollenberger, Dale Fonken, Brian Kesner, & Paul Marsh**

Utah Lake is home to an endemic population of June Sucker *Chasmistes liorus*. A decline in the June Sucker population led U.S. Fish and Wildlife Service to list the species as endangered in 1986. Extensive recovery efforts by the interagency group "June Sucker Recovery Implementation Program" (JSRIP), led to June Sucker being reclassified from endangered to threatened in 2021. Illegal introduction of Northern Pike *Esox lucius* into Utah Lake in early to mid-2000s may jeopardize June Sucker recovery. Presence of Northern Pike in Utah Lake was confirmed in sampling by Utah Division of Wildlife Resources (UDWR) in 2011. Because of the substantial threat Northern Pike pose to recovery, it was determined that research and monitoring for Northern Pike in Utah Lake should be initiated to a) identify Northern Pike spawning sites and aggregations; b) identify the best capture methods, and ultimately, control measures; and c) evaluate potential impact of Northern Pike on the June Sucker population. In

2021, a three-year research project was initiated by JSRIP in collaboration with Marsh & Associates and UDWR. This project implements a combination of acoustic and radio tracking, larval trapping, PIT Tag monitoring, and observation to describe Northern Pike movement, habitat use, congregational behavior, and spawning behavior in Utah Lake. Herein, we discuss results and findings from the first ~1.5 years of project work. At time of writing, 13 of 30 tagged Northern Pike in Utah Lake have been contacted by submersible ultrasonic receivers (SURs). These 13 fish account for a total of 10,179 telemetry contacts. SUR data show considerable variation in Northern Pike movement and congregational behavior in different seasonal intervals. Northern Pike movement slowly increases at lake ice-off at the end of winter and culminates in large congregations of Northern Pike entering the lake's tributaries to spawn during spring when water temperatures exceed 9.0℃. Fish disperse after spawning, but summertime acoustic telemetry and mechanical capture efforts have been unsuccessful at detecting fish so locations and movement patterns during warmer months remain unknown. Home range estimations indicate Northern Pike in Utah Lake exhibit a hybridized foraging behavior by using both littoral habitat and the pelagic zone. Preliminary results suggest early spring months may offer the best time to effectively target and remove significant quantities of Northern Pike from Utah Lake while minimizing bycatch of June Sucker.

09:15-09:30: Summary of AZGFD Conservation Efforts Through the Gila River Basin Native Fishes Conservation Program 2001-2022 – **Brian Hickerson, William Stewart, Kent Mosher, & Anthony Robinson**

The Arizona Game and Fish Department (in collaboration with other partner agencies), has implemented a program of nonnative fish eradication efforts and native fish translocations since 2001, as part of the Gila River Basin Native Fishes Conservation Program led by the U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service. These efforts have primarily focused on improving the conservation status of several priority species: Gila Topminnow, *Poeciliopsis occidentalis*, Spikedace, *Meda fulgida*, Loach Minnow, *Rhinichthys cobitis*, and Gila Chub, *Gila intermedia*. To date, the Department's efforts have resulted in the eradication of nonnative fishes from seven waters within the Gila River basin in Arizona. In addition, there has been a substantial increase in the number of extant populations of the priority species (and Desert Pupfish, *Cyprinodon macularius*) within the Gila River basin of Arizona as a result of translocations. Few relict populations of the priority species were lost within this period, resulting in a net increase in the number of populations for all focal taxa since 2001. The Department's efforts supported by the Gila River Basin Native Fishes Conservation Program have substantially benefited the conservation status of listed species and demonstrates that conservation actions can be effective when funding is consistent and targeted to actions most likely to move species toward recovery.

09:30-09:45: Application of next generation DNA sequencing markers for genetic monitoring of the endangered razorback sucker, *Xyrauchen texanus* – **Abby Wicks, Trevor Krabbenhoft, Joel Corush, Thomas Turner, Megan Osborne, & Thomas Dowling**

Next-generation DNA sequencing methods have become a fixture in population studies, providing many simple, easily scored DNA markers (single nucleotide polymorphisms – SNPs) that are useful for fine-scaled studies of important population parameters. We developed and applied a panel of SNPs for studies of endangered razorback sucker (*Xyrauchen texanus*) and are

using them to estimate key demographic and population genetic parameters linked to adaptive management. Characterization of stocked adults and progeny in off-channel refugia shows that SNP markers perform as well as, or better, than microsatellites for parentage assessment and for estimation of population genetic and demographic parameters. Characterization of SNPs from annual samples from Lower Colorado River populations provided estimates of population genetic parameters necessary for the long-term genetic monitoring program. SNPs are also useful for assessment of levels of introgressive hybridization between razorback and flannelmouth sucker (*Catostomus latipinnis*) in the Grand Canyon, where a sample of >1000 larvae in 2018 yielded only 14 razorback sucker. Of these, 635 flannelmouth sucker and eight razorback sucker remained after filtering of individuals with > 25% missing data. All eight razorback sucker exhibited signs of shared ancestry with flannelmouth sucker while approximately 2% of the 635 flannelmouth sucker larvae exhibited genetic variants from razorback sucker, consistent with past hybridization between species. Results validate the utility of SNP markers for conservation and management of endangered razorback sucker and other fishes.

09:45-10:00: 2022 Upper Colorado Area Report – **Dave Speas**

Drought in the Upper Colorado River Basin persisted in 2022, although river conditions in some areas were not as severe as the preceding year. Drought response releases from upstream reservoirs (Flaming Gorge, Aspinall Unit, Navajo) aimed at maintaining elevations in Lake Powell above critical operating levels were conducted for the second year in a row, with releases from Flaming Gorge Dam also supporting three flow experiments designed to benefit endangered fish. Research on eroding sediments with declining lake levels at the Colorado River inflow to Lake Powell revealed potential for emergence of pre-dam rapids and perhaps waterfalls. In Colorado, research on use of tributaries to the Gunnison and Colorado rivers by threatened and endangered fish continued, and aquaculture students at the Palisade High School Fish Hatchery released their second cohort of campus-reared razorback sucker into the Colorado River. In Utah, efforts to restore base flows in the Price River continued to advance, and research on development and persistence of complex habitat in the San Rafael River revealed potential benefits for threatened and endangered fish. The passage of the Bipartisan Infrastructure Law in late 2021 brought with it funding for the Upper Colorado and San Juan River endangered fish recovery programs, including support for improved hatchery resources, non-native fish screens, fish passages, wetland water control structures, and other projects. These stories and more will be covered in the 2022 Upper Colorado River Area Report.

10:00-10:15: Ongoing restoration projects for the endangered Moapa dace, *Moapa coriacea*, at the Moapa (Muddy) Warm Springs, Clark County, Nevada – **David Syzdek & Michael Schwemm**

The Moapa (Muddy) Warm Springs in Southern Nevada is a regional carbonate warm water spring complex that forms the headwaters of the Muddy (Moapa) River. These springs and associated streams are habitat for an endemic suite of thermophilic aquatic species that includes the federally endangered Moapa dace (*Moapa coriacea*). Currently, the Southern Nevada Water Authority (SNWA), US Fish and Wildlife Service (USFWS), Nevada Department of Wildlife (NDOW) and other stakeholders are undertaking recovery actions for the Moapa dace and its habitat. These include construction and removal of fish passage barriers, removal of invasive species and habitat restoration. To facilitate recovery of the Moapa dace and other

native species, SNWA purchased the 1,218-acre Warm Springs Ranch in September 2007 and designated it the Warm Springs Natural Area for conservation and environmental stewardship purposes.

In 2008, Moapa dace numbers suddenly declined to a record low of 459 individuals. Following this nadir, SNWA, NDOW and USFWS conducted stream restoration work and intensive habitat improvements to improve conditions for the Moapa dace. Since 2008, NDOW successfully treated the Upper Muddy River with rotenone to control the invasive and predatory blue tilapia (*Oreochromis aureus*). Furthermore, stream restoration and clearing of dense stands of invasive tamarisk (*Tamarix* spp.) and fan palms (*Washingtonia filifera*) are facilitating the re-establishment of native riparian vegetation, providing prevention of future wildfires and continued improvement in Moapa dace numbers. Moapa dace numbers are currently stable at a significantly higher level than in previous years but have yet to reach recovery levels of 6,000 fish. Recent snorkel counts recorded 1,956 Moapa dace in February 2022, and 2,221 Moapa dace in August 2022.

Work continues to improve dace habitat, improve stream connectivity, and to monitor for invasive species. In 2015, a removable fish barrier was opened to allow Moapa dace access to its entire historical range. In 2018, a property purchase by SNWA on the North Fork acquired additional habitat which is currently being restored. In 2019 and 2020, 88 Moapa dace were translocated into the South Fork and those fish have successfully reproduced and now have a stable population. In 2021, 90 Moapa dace were transferred to the Lake Mead Fish Hatchery for a NDOW fish propagation program. Fish produced in the hatchery will be used to augment wild populations. In 2022, USFWS constructed a new stream channel to replace a culvert and waterfall blocking fish passage. Stakeholders are currently assisting Desert Research Institute with developing techniques to estimate Moapa dace populations and monitor for invasive aquatic species using environmental DNA techniques.

10:15-10:30: **BREAK**

General Session – Moderator Chase Ehlo

10:30-10:45: Springsnails of Ash Meadows – **Harold Fairfield**

Ash Meadows is a desert oasis located in the southern portion of Nye County, Nevada as part of the Amargosa Desert. The numerous springs discharging here serve to concentrate a varied diversity of terrestrial and aquatic life. During 1985-1986 Robert Hershler and Donald Sada documented two genera of springsnails, *Pyrgulopsis* and *Tryonia* (Hershler & Sada, 1987) from these springs. Of the 11 species found, 9 were described as new species and 10 are endemic to specific spring habitats at Ash Meadows. These authors included descriptions and graphics of shell and penis variations for species diagnosis. This presentation is a compilation of shell, penis, and locality features serving to better understand the characteristics and distribution of Ash Meadows springsnails.

10:45-11:00: Back to the future, warmwater fish in the Grand Canyon – **David Rogowski**

The Colorado River was historically a warmwater system until dams were installed. Prior to Glen Canyon dam the most common fishes were Channel Catfish and Common Carp. After the dam cool water releases reduced the number of these two nonnative species, but they still were very common from 2000-2010. Around 2010 as water levels began declining in Lake Powell and Lake Mead, the abundance and distribution of these two species within the Colorado River, Grand Canyon also declined. The decline occurred in part due to the formation of Pearce Ferry Rapid, and potentially the loss of warmwater backwater areas in western Grand Canyon as Lake Mead shrank and the Colorado River re-emerged. As Lake Powell declines the release water has increased and areas formerly to cold for reproduction of a variety of species are now within their reproduction range. In 2022 Common Carp, Green Sunfish, and Smallmouth Bass successfully spawned in a slough three miles below Glen Canyon Dam. What does the future hold for the Colorado River native fish assemblage when water temperatures are now within the range of a variety of nonnative fish that are relatively common within Lake Powell and Lake Mead? Will it return to a system dominated by nonnative fish again?

11:00-11:15: A small warm tributary provides prespawning resources for Colorado Pikeminnow in a cold dam-regulated river – **Edward Kluender & Kevin Bestgen**

Riverine habitat mosaics, including tributaries, are an important reason the Green River subbasin supports the largest remaining population of federally endangered Colorado Pikeminnow, *Ptychocheilus lucius*, in the Colorado River Basin. Upstream Colorado Pikeminnow distribution is limited by Flaming Gorge Dam and few typically occurred in the reach immediately downstream of the dam, which is most affected by thermally and hydrologically altered dam releases. However, fish captures and passive integrated transponder (PIT) antenna sampling of previously tagged individuals from 2011-2021 revealed seasonal congregations of up to 75 Colorado Pikeminnow annually in the mouth of Vermillion Creek, a small tributary in the regulated reach. Approximately 11% of the entire 2017-2018 Green River basin population (N=93 individuals) were encountered in Vermillion Creek over the 11-year study, an underestimate of use considering untagged fish were not detected by antennas. Colorado Pikeminnow used Vermillion Creek primarily when Green River spring flows from Flaming Gorge Dam were high and cold in May through mid-June when the confluence was a large, deep backwater that was warmer than the main channel and supported forage fishes. Intra-annual encounters revealed seasonal residence times for individual Colorado Pikeminnow up to 91 days, and multiple inter-annual encounters indicated site fidelity. Frequent detections of individual Colorado Pikeminnow in a Yampa River spawning area soon after their detections in Vermillion Creek indicate this tributary may be an important resource for reproductive adults. The intensive and basin-wide PIT tagging and detection program for Colorado Pikeminnow enhanced our understanding of the importance of small habitat nodes such as Vermillion Creek in the Green River drainage network. Understanding and protecting these seasonally available riverine habitat mosaics used for prespawning conditioning may assist with recovery of Colorado Pikeminnow.

11:15-11:30: Advances in genetic knowledge for the management & conservation of the Sonoyta River Mexican Longfin dace, *Agosia chrysogaster* in Northwest Mexico – **Alejandro Varela-Romero, Marisol A. Paredes-Gallardo, Carlos A. Ballesteros-Córdova, Manuel Grijalva-Chon, Enrique De la Re-Vega, Alexsandre Gutiérrez-Barragán, & Nélida Barajas-Acosta**

The Sonoyta River Basin is a binational watershed and home native Sonoyta pupfish, *Cyprinodon eremus*, and the Sonoyta River Mexican Longfin dace, *Agosia chrysogaster*, that evolved to survive the harsh conditions of the Sonoran Desert. Due to the decline of both, refuge network was built in Sonora with individuals from the Sonoyta River as a conservation strategy between 2007 to 2010. However, its establishment did not consider well the genetic variability of the source population. We evaluated the specific identity and phylogenetic affinity of *A. chrysogaster* populations of wild population and refuge using mitochondrial (Cytb and COXI) and nuclear DNA (RAG1). For the Longfin dace we find monophyly for all populations without geographic clades. The mitochondrial and nuclear signal support an independent clade of the Sonoyta River (Refuge), nested within all the individuals analyzed. The genetic variability was high between populations and high genetic differentiation. The barcode (COX1) showed fixed polymorphism showing divergence in specimens analyzed of the Sonoyta River (CEDO) population and does not share haplotypes with the rest of the basins and the genetic diversity was zero. The Sonoyta population divergence needs to be verified with additional genetic marker (Genome) and morphological evidence, without delaying urgent recovery and conservation efforts for this unique captive population.

11:30-11:45: Fish Behavior & Mortality During a Monsoonal Spate in the San Juan River, UT, USA – **James Whitney, Blake Hansen, Amber Bell, & Michaela Fishback**

The Southwestern United States monsoon season can produce heavy precipitation that results in high flow events. Fish kills can occur when these monsoonal freshets derive from runoff over recently-burned catchments, but less is known concerning monsoonal-induced fish kills occurring in unburned riverscapes. Here we report on a fish kill unrelated to wildfire that occurred following a monsoonal spate in the San Juan River, Navajo Nation, Utah, United States, which we observed while camped on an island (latitude = 37.12657, longitude = -109.10227) on 24-25 July 2021. During this event discharge increased by 152 cubic meters/second (5,368 cubic feet/second) in 2.5 hours (i.e. 8:30-11:00 PM on July 24). At the peak of the high flow there were numerous fishes that sought refuge in the slack water amid the flooded vegetation of our island. Many of these fishes were lethargic and gulping for air, although some also appeared to be surface feeding. By the morning of July 25th waters had receded, leaving behind numerous dead fishes. We inventoried all the dead large-bodied (i.e. total length ≥ 100 mm) individuals we could find along a 70 m search path on the eastern side of the island, where we located 14 Channel Catfish, *Ictalurus punctatus*, 5 Bluehead Sucker, *Catostomus discobolus*, 4 Colorado Pikeminnow, *Ptychocheilus lucius*, 3 Flannelmouth Sucker, *Catostomus latipinnis*, and 1 Razorback Sucker, *Xyrauchen texanus*. We also observed dead small-bodied (i.e. total length < 100 mm) individuals that were too numerous to count, including Channel Catfish, Fathead Minnow, *Pimephales promelas*, Red Shiner, *Cyprinella lutrensis*, Speckled Dace, *Rhinichthys osculus*, Virile Crayfish, *Faxonius virilis*, and hellgrammites (Order Megaloptera, Family Corydalidae). Finally, we also note that on the morning of July 25th there were living Channel Catfish on our island that were stranded in remaining pools. We suspect that hypoxia and high suspended sediment loads caused organisms to suffocate, but more research is necessary to identify the cause of death.

11:45-12:00: Hatchery propagation & augmentation slow, but do not prevent, genetic erosion in Rio Grande Silvery Minnow – **Megan Osborne, Guilherme Caeiro-Dias, Thomas Archdeacon, Robert Dudley, Charles Yackulic, & Thomas Turner**

Strategic planning and successful conservation of imperiled species require accurate information about demographic trends. Monitoring genetic effective population size (Ne) has also been widely advocated in conservation programs because it is an important predictor of adaptive potential. Genetic (microsatellites and single nucleotide polymorphisms [SNPs]) and demographic monitoring data of wild-born and augmented fish, spanning the most recent megadrought (2000–2022), were used to examine relationships between estimated abundance and contemporary Ne in the endangered Rio Grande Silvery Minnow, *Hybognathus amarus*. Estimates of the fraction of the population comprised of augmented fish were significantly correlated with genetic estimates of gene flow between these population components. Estimates of variance effective population size (NeV) of the entire population (augmented and wild-born) were less than estimates of wild-born NeV. This result shows that augmentation serves as an additional source of genetic drift. Analysis of temporal divergence shows a shift in allele frequencies after the 2012–2014 drought-induced population bottleneck. When a greater fraction of the population comprised hatchery fish, genetic effective size was reduced. Extending analyses to SNP-based microhaplotypes revealed recent reductions in observed heterozygosity and increases in inbreeding metrics. Together, our results show that hatchery propagation and augmentation slow, but do not prevent, genetic erosion in Rio Grande Silvery Minnow.

12:00-13:30: **LUNCH**

General Session – Moderator Michael Bogan

13:30-13:45: Flathead catfish upstream expansion as a threat to native fish conservation in the lower Colorado River – **Chase Ehlo & Kirk Young**

The Lower Colorado River harbors eight species of native fish with many special morphological and life history traits in response to this unique desert aquatic ecosystem. Four of these species are endangered, primarily due to habitat alterations from dams and predation and competition by nonnative aquatic species. One such nonnative species, Flathead Catfish, is historically native to the Great Lakes and Mississippi River Basin. The species is a voracious predator with liberal gape width limitations; as a result, this introduces new challenges to the conservation efforts of endangered fish in the Lower Colorado River below Davis dam and potentially upstream. It was stocked in the Southwest as early as the 1940s and has since expanded into many important desert stream systems such as the Gila and Salt rivers in eastern and central Arizona and the Lower Colorado River in Western Arizona and California. It is difficult to pinpoint how or when Flathead Catfish were first detected in Lake Havasu but it is suspected that it was a result of angler introductions in the 1980s from below Parker Dam. Nevertheless, the species slowly expanded throughout the lake and has begun to encroach on native fish populations, particularly Razorback Sucker, in the riverine sections upstream of Lake Havasu. Arizona Fish and Wildlife Conservation Office biologists, with partners, identified an upstream threshold in the river with the intention of preventing further upstream movement of the species. However, recent targeted surveys in 2021 and 2022 have detected around 40 individuals immediately downstream and up to 20 river miles upstream of this threshold. Specimens ranged from 202 – 775 mm indicating evidence of recent recruitment and multiple size classes. If the species continues to expand upstream, and over or through major dams it could not only threaten years of conservation work in Lake Havasu but upstream waters such as Lake Mohave, Lake Mead, and the Grand Canyon.

13:45-14:00: Hydrology to guide conservation: a gain-loss study in the Devils River, Texas – **David Young & Sarah Robertson**

In groundwater dependent streams that support stable habitats and highly endemic species, environmental heterogeneity along the stream gradient creates a mosaic of habitats that change through time and space. In karst settings, stream-aquifer interactions in the form of streamflow gains (springs) and losses (aquifer recharge) have been shown to influence habitat complexity and aquatic assemblages. The spatial and temporal patterns of gains and losses are important to understanding the relationship between groundwater and streamflow and for identifying factors that promote or limit species distribution. The Devils River, considered by many to be the most pristine and ecologically intact river in Texas, is home to federal and state listed fish and mussel species. Coarse streamflow studies have been previously conducted however, high spatial resolution gain-loss data is lacking, as are measurements recorded over various hydrologic conditions. This study provides a systematic, fine-resolution gain-loss study along 42 miles of the spring-fed Devils River of the Edwards-Plateau Aquifer in south-west Texas. Discharge measurements were repeated at 20 sites across five events in 2021 and 2022. Results indicate a spatially consistent pattern of gains and losses despite varying flow conditions with two significant gaining reaches and two losing reaches which decreased streamflow by approximately 10 and 70% respectively. This study supports refinements to the conceptual

model of the aquifer and allows for a better understanding of surface-groundwater interactions for the Devils River, something critical to understanding the relationship between environmental conditions and available habitat for imperiled species. The implications suggest that groundwater conservation management should focus on springs and spring habitats and include losing reaches which are the most suspectable habitat to drying. This along with other hydrology and biology data collection efforts are critical in informing future water management strategies protective of native species habitats in this groundwater dependent system.

14:00-14:15: Native Fish Need a Natural Flow Regime, Not More Water Development – **Phaedra Budy, Casey Pennock, William MacFarlane, Mathew Breen, John Schmidt, & Justin Jimenez**

Water development has threatened the ecological integrity of riverine ecosystems. Increasing demand for water, persistent drought, and climate change exacerbate the effects of habitat degradation and loss in altered systems such as the Colorado River basin, USA. Today, biologists in the basin are challenged to identify management actions that benefit native fishes while not hindering water development or management. Herein, we discuss the importance of the natural flow regime for functioning riverine ecosystems and provide examples from four tributaries to the middle Green River, a major headwater branch of the Colorado River. These rivers represent a gradient of impacts ranging from water abstraction to the point of complete seasonal desiccation to a relatively natural flow regime, and consequently have maintained different levels of in-stream habitat complexity and native fish persistence. Despite decades of intense management, endangered species continue to lack self-sustaining populations and other imperiled native species have been extirpated from over half their ranges, which begs the question of whether water development and fish conservation can be balanced? Given the continued decline in freshwater biodiversity and abundance occurring across the globe, we contend rivers with natural flow regimes should be considered for immediate protected status as freshwater conservation areas.

14:15-14:30: Is recovery & delisting possible for conservation-reliant species? A case study of the Apache Trout in Arizona – **Jess Newton**

It is increasingly common for species listed under the Endangered Species Act to be considered “conservation reliant” for the foreseeable future. Conservation-reliant species are defined as requiring some level of management to remain viable as a species even when recovery goals for self-sustaining populations are met. This raises questions about the possibility of delisting species that remain vulnerable to ongoing threats. We present a case study of an endemic trout in the arid southwest, the Apache Trout (*Oncorhynchus apache*). The U.S. Fish and Wildlife Service recently recommended delisting of the Apache Trout due to recovery. Apache Trout fits the definition of a conservation-reliant species because some threats will persist or periodically reappear into the future, such as competition and predation by nonnative fish, hybridization, and wildfire. The recommendation to delist was partially influenced by the implementation of a voluntary in-perpetuity Cooperative Management Plan that outlines partner commitments to Apache Trout conservation regardless of listing status. The development of cooperative management plans is an emerging method of addressing the recovery and delisting needs of conservation-reliant species.

14:30-14:45: Loach Minnow & Spikedace mesohabitat use across space with varying abundances – **Crosby Hedden & Brian Hickerson**

Two fish species endemic to the Gila River basin, Spikedace, *Meda fulgida* and Loach Minnow, *Tiaroga cobitis*, are both thought to have strong habitat associations that restrict their potential distributions. Previous studies support the concept that Loach Minnow are riffle specialists, while research describing Spikedace habitat use varies. Our objective was to determine if mesohabitat associations are similar across stream reaches, and to observe if these patterns are consistent when local abundances change through time. We analyzed long-term monitoring data (2008-2021) from three stream reaches where populations of Spikedace and Loach Minnow previously existed or were translocated (Hot Springs Canyon, lower Blue River, middle Blue River). During the years covered by the dataset, Spikedace failed to establish a population in Hot Springs Canyon, began to establish a population in the middle Blue River, and established an extremely abundant population in the lower Blue River following translocation efforts. Translocations of Loach Minnow resulted in the establishment of a relatively small population in Hot Springs Canyon, and helped reestablish a robust population in the lower Blue River following impacts from the Bear Wallow Fire. The Loach Minnow population in the middle Blue River is a robust relict population that never received any translocations. We estimated relative abundance across three mesohabitat types (pool, riffle, run) for each year of monitoring. Each fish was captured in all three mesohabitats, although not evenly between them at all time. Loach Minnow relative abundance was significantly different among mesohabitat types, with relative abundance in riffle habitats being greater than in run or pool habitats at all reaches. No differences were observed in the relative abundance of Spikedace among habitats at any reach with the exception of the lower Blue River, where they utilized riffle and run habitats significantly more than pools. Further, we found a significant shift in Spikedace habitat use in the lower Blue River as abundances increased through time, where they utilized riffle and run habitats more following proliferation. Our results are consistent with previous studies in that Loach Minnow generally occupy riffle habitat while Spikedace habitat use appears to be less constrained by mesohabitat type at low relative abundances, and shifts to more specific mesohabitat types with increasing relative abundance.

14:45-15:00: Update on taxonomic & conservation status of North American blindcats (Ictaluridae) – **Dean A. Hendrickson, John Lundberg, Luckenbill Kyle, & Mariangeles Arce-H**

We provide an updated overview of the taxonomic and conservation status of all North American blind Ictalurids, and continuing efforts to better understand them. In Texas' deep Edwards Aquifer under San Antonio, *Satan eurystomus* (Widemouth Blindcat) has not been collected since 1984, but fragments of *Trogloglanis pattersoni* (Toothless Blindcat) continue to appear occasionally from the only well still consistently available for sampling, providing material for its recently published complete mitogenome. A metabarcoding-based eDNA sampling project hoping to detect blindcats (and other taxa) is now in early testing in wells throughout the San Antonio area. Lack of access to wells remains a major roadblock for that effort, but we have promising outreach efforts developing that we hope will open doors for sampling in the near future. In the adjacent transboundary Edwards-Trinity Aquifer, new localities have been found for *Prietella phreatophila* (Mexican Blindcat) in both Coahuila and Texas, and a captive colony at San Antonio Zoo continues to thrive and grow. Two complete mitochondrial genomes from 2 specimens of this species using different methodologies are now available. We present new CT data that indicate specimens from a cave ~25 km N of the type

locality of *Prietella lundbergi* (Phantom Blindcat) in Tamaulipas, México, initially reported as that species, represent an undescribed taxon. Multiple attempts by divers to obtain additional specimens of *P. lundbergi* from the type locality have failed, leaving the formalin-preserved holotype as the only specimen of that species.

15:00-15:15: **BREAK**

General Session – Moderator David Rogowski

15:15-15:30: What can population genomics tell us about conservation of the imperiled Peppered Chub (*Macrhybopsis tetranema*)? – **Guilherme Caeiro-Dias, Megan Osborne, & Thomas Turner**

Peppered Chub (*Macrhybopsis tetranema*) is part of the *Macrhybopsis aestivalis* complex, which comprises nine recognized species, and belongs to the pelagic-broadcast spawning guild of fishes. This guild is adversely affected by fragmentation, altered flow regimes, habitat degradation of rivers of the North American Great Plains. Survival and reproductive success are positively linked to river discharge and connectivity. Peppered Chub is extirpated from more than 94% of its historic range and only occurs in a 218-kilometer reach of the South Canadian River between Ute Lake (New Mexico) and Lake Meredith (Texas). We assessed genomic diversity across this remnant population, evaluated genetic differentiation between several geographical and temporal samples, and estimated genetic effective population size (Ne) from Peppered Chub collected between 2015 and 2020. We identified 1627 SNP-containing loci (microhaplotypes), obtained from 189 individuals sampled across six temporal collections from several localities across the South Canadian River. Genome-wide diversity metrics were virtually identical across localities and across the time-series. Recent collections (2018 – 2020) show an order-of-magnitude reduction in Ne in 2019 that coincides with an exceptional drought. There was little genetic differentiation across sites or between sampled years in New Mexico. Likewise, we did not observe differentiation between New Mexico sampling localities and a single site upstream of Lake Meredith, Texas. Additional sampling and genetic analyses of samples collected from the border of New Mexico and to Lake Meredith is warranted to assess our findings more robustly. Based on our microhaplotype markers, future work should include the development of a panel of SNP-based markers to continue genetic monitoring and inform management decisions including establishment of a refuge population.

15:30-15:45: Bridging the recruitment gap: ten years of managing flows & habitats to improve recruitment of wild Razorback Sucker, *Xyrauchen texanus* – **M. Tildon Jones, Kevin R. Bestgen, David W. Speas, Matthew J. Breen, Christian T. Smith, Robert C. Schelly, & Michael S. Partlow**

The Upper Colorado River Endangered Fish Recovery Program manages river flows and wetland habitats in the Green and upper Colorado rivers to increase recruitment of wild-spawned Razorback Sucker. Since 2012, experimental spring peak releases from Flaming Gorge Dam are timed to coincide with the presence of drifting river-produced Razorback Sucker larvae that are subsequently entrained into warm, food-rich floodplain wetlands. These experiments are based on previous data on the timing of larval drift, dam release operations, and habitat availability and fish use, which led to the development of the “Larval Trigger Study Plan.” Initially, biologists inundated a single wetland, Stewart Lake, which was managed as a native fish nursery habitat.

In the last 10 years, the Program has constructed four additional managed wetlands and re-operated a fifth to improve Razorback Sucker growth and recruitment. These sites share common features designed to facilitate juvenile survival including: 1) a water control structure that regulates filling and draining of the habitat; 2) screens to reduce wetland colonization by adult nonnative fishes during filling; and 3) a mechanism to add water during hot summer months to improve water quality. After wetlands are filled with cold river water during spring flows, entrained Razorback Sucker larvae grow relatively quickly through the summer season. At the end of summer, or when water quality cannot be maintained, wetlands are drained, juvenile fish are collected for enumeration and tagging, and native fishes are released back to the river. The resulting wetland operations have increased our knowledge of the species' life history while producing over 5,000 wild, juvenile Razorback Sucker. In addition, forty-eight presumptive wild Bonytail, Gila elegans, have been produced in two of these managed wetlands. In 2020, wetland-reared Razorback Sucker larvae were first observed as age-6 adults at known spawning locations. Additional wild Razorback Sucker are needed to maintain riverine populations, therefore wetland managers continue to refine their operations, address challenges, and improve facilities in the face of increased conservation challenges from drought, climate change, and invasive species.

15:45-16:00: Oxygen Manipulation for Fisheries Management – **David Ward & Eric Frye**

Sodium Sulfite can be used to remove the oxygen out of pond or stream causing the fish to come to the surface so they can be caught. Any fish that are desired to be kept can be revived in fresh water. Sodium sulfite is a powerful oxygen scavenger that is used to preserve meat and dried fruit and is non-toxic and approved for people to eat. We quantified the effective dose of sodium sulfite in the laboratory for fish removal and then conducted replicated field trials in a small-lined research pond. Sodium sulfite dispensed at 1.3 g/L rapidly (< 15 min) decreased dissolved oxygen to < 1 mg/L causing fish to gulp at the surface allowing them to be captured with a hand net. Oxygen levels typically return to baseline conditions within 24-hours. Manipulation of dissolved oxygen may have advantages over other fish removal methods in that water quality conditions quickly return to pre-treatment conditions with no harmful residues and minimal impact to non-target species or the environment. Additional tools for control of invasive aquatic species are sorely needed and although this particular tool may only be effective in small, isolated bodies of water, the addition of any new tool for invasive fish management is helpful in the ongoing battle to prevent extinctions of southwestern native fishes.

16:00-16:15: Common Carp - Uncommon Predator! – **Eric Frye & David Ward**

Predation by common carp (*Cyprinus carpio*) on humpback chub (*Gila cypha*) has the potential to be high with negative impacts to humpback chub recruitment. We evaluated predation effects of common carp on humpback chub eggs, larvae and juveniles in the laboratory. We extracted and fertilized humpback chub eggs from captive reared adult chub and placed 1 ml of fertilized eggs onto cobble in each of 9, 150-gallon tanks at 20°C with either 2 common carp (6 replicates), or no carp (control, 3 replicates). Eggs were exposed to these treatments for 24-hours and then fish were removed. After 10 days, humpback chub larvae were counted. Treatments with common carp experienced a 97% reduction in humpback chub egg and larval survival. Experiments were then scaled-up in size to verify that this effect was not the result of

small tank size. An additional 12 trials (6 with carp and 6 without carp) were conducted in 500-gallon raceways with similar results. Humpback chub eggs and larvae again experienced over 90% reduction in survival when compared to control trials with no carp present. Additional 24-hr laboratory predation trials were conducted using captive reared juvenile bonytail (*Gila elegans*) (22-70 mm TL) humpback chub (21-49 mm TL) and razorback sucker (*Xyrauchen texanus*) (47-98 mm TL) as prey. Chubs and suckers both experienced unexpectedly high predation mortality with the smallest sizes being most vulnerable. These results demonstrate that common carp are not just a threat to eggs and larval native fish, but also to juveniles. This information gives context about potential management actions designed to conserve Colorado River native fishes. Additional carp-focused management actions within the Little Colorado River may be warranted to conserve imperiled native fishes.

16:15-16:30: Bonneville Basin Area Report – **Sarah Seegert**

Conservation activities in the Bonneville Basin continue to focus on a variety of habitats and taxonomic groups. These activities are guided by many programs, including: the June Sucker (*Chasmistes liorus*) Recovery Implementation Program, the Utah Statewide Mollusk Conservation Strategy, and the Conservation Agreements for Bonneville Cutthroat Trout (*Oncorhynchus clarkii utah*), Boreal Toad (*Anaxyrus boreas boreas*), Northern Leatherside Chub (*Lepidomeda copei*), Southern Leatherside Chub (*Lepidomeda aliciae*), Columbia Spotted Frog (*Rana luteiventris*), Least Chub (Iotichthys phlegethontis), Three Species (specifically Bluehead Sucker; *Catostomus discobolus*), Sub-glubose Snake Pyrg (*Pyrgulopsis saxatilis*), and other Great Basin Springsnails. June Sucker recovery continues, with the Provo River Delta Restoration project to be completed in 2023, following a downlisting rule in February 2021. Habitat restoration and range expansion continue for many of the above-mentioned species, especially Southern Leatherside, Least Chub, Columbia Spotted Frog, and Bluehead Sucker. Future conservation actions can be guided by the recently completed Multispecies Aquatic Assessments for the Bonneville, Lahontan, and Central Nevada Basins, funded by the Desert Fish Habitat Partnership. The assessment is available in a report and as a webtool (https://trout.maps.arcgis.com/apps/webappviewer/index.html?id=f82cf3ef5ae64c83ab10c39f0cce4656).

16:30-18:00: **Business meeting – main conference room (next page):**

18:30-22:00: **Banquet – main conference room:**

DESERT FISHES COUNCIL 54TH ANNUAL SYMPOSIUM, 2022 – ST. GEORGE, UTAH
BUSINESS MEETING
NOVEMBER 18, 16:30-18:00

I. Welcome & call to order – Kevin Wilson, President
    a. Discussion & approval of 2021 Business Meeting minutes
    b. President's report

II. Executive Committee Reports
    a. Immediate Past President – Megan Bean
    b. Treasurer, Executive Secretary, Membership Secretary – Stewart Reid
    c. Member-at-Large – Melissa Trammell
        i. 2022 Grants
        ii. Nominations & voting for Member at Large & Membership Secretary
    d. Student awards – Krissy Wilson
    e. Areas Coordinator – Michael Schwemm
    f. Outreach Coordinator – Heidi Blasius
    g. Program Secretary – Chris Hoagstrom
    h. Proceedings Editor & Data Management, Webmaster – David Rogowski

III. Old Business
    a. Phil Pister project update – Freshwaters Illustrated – Jeremy Monroe
    b. 2023 Meeting – Kevin Wilson
    c. Call for additional old Business – Kevin Wilson

IV. New Business
    a. Future meeting at Cuatro Ciénegas – Dean Hendrickson
    b. Call for additional new business – Kevin Wilson

V. Adjourn

SATURDAY MORNING, NOVEMBER 19 – MAIN CONFERENCE ROOM

07:30-08:30: Presentation loading in person (if not emailed ahead of time)

08:30-08:45: Welcome – Kevin Wilson, President

General Session – Moderator Jennifer Graves

08:45-09:00: Upper/Middle Rio Grande & Pecos rivers, including Arkansas, Tularosa & Guzman basins of New Mexico Area Report – **Joanna Hatt, Bryan Bakevich, Thomas Archdeacon, Stephen Davenport, Robert Dudley, Bryan Ferguson, Eliza Gilbert, Jasmine Johnson, Megan Osborne, Yvette Paroz, & Thomas Turner**

The Upper/Middle Rio Grande and Pecos rivers Area Report will provide an overview of research, monitoring, and recovery efforts for fishes of the region in 2022. This year's accomplishments included: establishment of new populations of Rio Grande Chub *Gila pandora* and Rio Grande Sucker *Catostomus plebeius*, initiation of a rangewide genomics study of Pecos Pupfish *Cyprinodon pecosensis*, successful post-fire rescue efforts of populations of Rio Grande Cutthroat Trout *Oncorhynchus clarkii virginalis* and Chihuahua Chub *Gila nigrescens*, and continued long-term monitoring of Rio Grande Silvery Minnow *Hybognathus amarus*, Pecos Bluntnose Shiner *Notropis simus pecosensis*, and White Sands Pupfish *Cyprinodon tularosa*. Additional highlights will also be discussed; e.g., the discovery of Gray Redhorse *Moxostoma congestum* persisting in the Delaware River after an extended dry period, and the agency partnerships that have resulted in conservation actions to benefit Canadian River fishes.

09:00-09:15: Conservation & Management of Aquatic Systems in Texas – **Megan Bean, Gary Garrett & Sarah Robertson**

This Texas area report for the Chihuahuan Desert region will focus on recent conservation, restoration, and research activities in aquatic systems and species.

09:15-09:30: Research, management, recovery partnerships, & updates for the Devils Hole pupfish – **Ambre Chaudoin, Jeffrey Goldstein, Kevin Wilson, John Wullschleger, Michael Bower, Olin Feuerbacher, Jennifer Gumm, Alex Jones, Michael Schwemm, Brandon Senger, Mark Hausner, & John Umek**

The Devils Hole pupfish (*Cyprinodon diabolis*) population has seen numerous highs and lows over the years. Climbing back from the brink of extinction and a record low of 35 fish in 2013, the 2022 spring and fall counts produced the highest population estimates in nearly two decades. Visual surveys, using standard methodology (SCUBA and surface counts), recorded an estimated 175 fish in spring 2022, the largest spring count since 2000 when the population was an estimated 190 fish. Fall 2022 surveys recorded 263 fish, an increase of 51% over the fall 2021 count which recorded 174 fish. This latest estimate represents the largest fall count since 2003 when the population was an estimated 297 fish, and the first time in 19 years the count has been greater than 200. Collaborative research and management currently focus on research gaps and implementation of the recently completed Devils Hole Pupfish Strategic Plan, including development of an emergency evacuation plan, genetic management plan, and other specific protocols. Additionally, the ICT is working with the Desert Research Institute on two separate projects. The first is a data synthesis project encompassing nearly 10 years of monitoring data

(2011-2019) from the Devils Hole long term ecosystem monitoring plan, plus other abiotic and biotic datasets going back to the 1960s; the second is a food web study to investigate trophic dynamics within the ecosystem, using stable isotope analysis techniques for comparison with previous food web studies in Devils Hole, yielding insights into the incorporation of natural and supplemental feeding.

09:30-09:45: Utilizing Geometric Morphometrics & Artificial Intelligence to Identify Early Life Stages of Klamath Suckers to Support Hatchery Operations – **Josh Rasmussen, Jane Spangler, & Michelle Jackson**

The artificial propagation program for the endangered shortnose sucker, *Chasmistes brevirostris*, and Lost River sucker, *Deltistes luxatus*, relies on larvae collected from the natural spawn to generate numbers each year. The resulting cohorts include individuals from the two listed species as well as Klamath largescale sucker, *Catostomus snyderi*. These species are closely related but readily distinguished with external morphology as adults. However, classifying Klamath sucker larvae and juveniles by morphology is extremely difficult and likely unreliable. To date, attempts to identify early life stage Klamath suckers has been largely qualitative. However, even quantitative studies have struggled to separate the three species due to hybridization (Markle et al. 2005, West. N.A. Nat. 65:473-489). To promote quantitative, reliable identification of juvenile Klamath suckers in the Klamath Falls National Fish Hatchery, we collected high quality ventral head (i.e., lips and mouth) digital images, digitized six landmarks to capture lip and mouth morphology, and standardized the landmarks using General Procrustes Analysis. The standardized data were used to generate relative warps to identify how many groups were present and inputted into a neural network to determine how best to describe those groups. Discovered groups in our data corresponded predominantly to the three species, indicating that morphological differences existed even at relatively smaller sizes, even though such differences are challenging to see with the naked eye. The neural network model adequately identified individuals in the validation set to the correct species. This approach can provide real-time species identification at a fraction of the cost of genetic alternatives, while potentially leading to a greater understanding of the dynamic of hybridization in conjunction with genetic analyses. Automation of image and data collection with a handheld digital device (e.g. a tablet) is necessary to make the methodology useful in real-time. Refinement of the neural network model (e.g., optimizing the number of hidden layers and nodes) is needed to maximize model utility.

09:45-10:00: Identifying demographic uncertainties & vulnerabilities in an invasive Smallmouth Bass population: Implications for reservoir management & mechanical removal efforts – **Lindsey Bruckerhoff, Charles Yackulic, Drew Eppehimer, & Kevin Bestgen**

We developed a population model for Smallmouth Bass (*Micropterus dolomieu*) in the middle Green River of the upper Colorado River basin. This model can be used to compare population responses of *M. dolomieu* to future environmental variation and management scenarios. Developing a tool to identify and compare management strategies to control *M. dolomieu* is a priority because the species is considered a top threat to the recovery of federally listed fish species in the Upper Colorado River basin. The model integrates long-term *M. dolomieu* catch-effort data, abundance estimates, and early life history data and links interannual variability in demographic rates to environmental conditions in two river reaches. We used the model to

identify and compare drivers of *M. dolomieu* population change, including hydrology, river temperature, exploitation, and immigration, and quantify uncertainty associated in these drivers. We determined there is substantial uncertainty regarding the extent to which population dynamics in the middle Green River are driven by immigration from the Yampa River and tributary reservoirs versus local recruitment. This uncertainty, in turn, makes it difficult to identify how effective management, including reducing age 0 survival and removing all size classes, needs to be to create meaningful, long-term reductions in abundance of *M. dolomieu*. Integrating additional data and learning from application of ongoing experimental management efforts could reduce this uncertainty over the coming years.

10:00-10:15: White River Spinedace Seasonal Survival & Movement in Flag Spring, Nevada – **Summer Burdick, Mark Beckstrand, James Harter, & Rachael Paul-Wilson**

White River spinedace were common in seven springs in Nevada's White River Valley in the late 1940s but since then their distribution and abundance declined due to hydrologic alterations and introduced species. By 1991 the only known White River spinedace in existence were 37 large and presumably old fish in the upper most 70 m reach of the north fork of Flag Spring. To prevent their extinction, largemouth bass were eradicated from a 3 km section of the Flag Springs complex and 20 White River spinedace were moved 200 m to downstream lotic habitat. These fish reproduced and the species is now distributed throughout the Flag Springs complex. A second reintroduction into Indian Spring was attempted but spinedace failed to reproduce. Before attempting another conservation introduction, information is needed on spawning behavior and habitats, and adult survival. Spinedace were captured in minnow traps and PIT tagged on four semi-annual occasions from November 2020 to June 2022. These fish were redetected during subsequent capture events and on antennas installed throughout the Flag Springs complex. Both physical recaptures and remote detections of tagged fish were used to estimate survival using a Barker Model. While spinedace were distributed throughout the complex, they were concentrated in cooler water habitats in the north and middle forks of Flag Springs and in upper Sunnyside Creek and avoided the warmer south Flag Spring. White River spinedace did not exhibit seasonal movements indicative of spawning. The probability of recapture was 0.36 (CI=0.21-0.54) and the probability of remote redetection was ≥ 92%. Semi-annual survival of White River spinedace >70 mm standard length, was 0.41 (CI= 0.30-0.53).

10:15-10:30: **BREAK**

General Session – Moderator Kevin Conway

10:30-10:45: Environmental DNA (eDNA) for Early Detection of Invasive Aquatic Species & Endemic Fish Surveillance in Desert Spring Systems – **Duane Moser, Victoria Wuest, & Michael Schwemm**

Aquatic organisms continuously shed DNA into their surroundings. This "environmental DNA (eDNA)" is detectable with exquisite sensitivity through the quantitative Polymerase Chain Reaction (qPCR). qPCR is routinely being used for the tracking of coldwater fish (e.g. salmonids) and to infer the invasion of the Great Lakes by Asian carp from the Mississippi River system. Much less is known, however, concerning the efficacy of these approaches for detection of

warm-water species. Spring-fed systems of the US Great Basin are home to a diversity of endemic and/or threatened aquatic organisms. The fortunes of these organisms are tied to hydrologic variables and competition/predation from invasive species (e.g. introduced fishes and red swamp crayfish (*Procambarus clarkii*)). However, molecular detection approaches are just beginning to be applied for the management of sensitive desert aquatic ecosystems.

Our proof-of-concept study is in progress and endeavors to optimize sampling (e.g. high-volume filtration) and DNA extraction protocols to maximize method sensitivity. Concurrently, published and custom-designed molecular probes (qPCR primer sets) targeting mitogenome targets are being evaluated to demonstrate that endemic fishes (e.g. Moapa dace (Moapa coriacea) and Warm Springs pupfish (*Cyprinodon pectoralis nevadensis*)) and invasive species (Red Swamp crayfish, blue tilapia (*Oreochromis aureus*), and red shiner (*Cyprinella lutrensis*)) can be quantitatively monitored in two priority ecosystems (the Muddy River and Ash Meadows in Southern Nevada). In parallel, the work aims to confirm the presence or absence of invasive tilapia and red shiner (Muddy River) and red swamp crayfish (Ash Meadows) in reaches where they have recently been removed.

Initial work with published qPCR primer sets targeting Eurasian dace performed well for Moapa dace, but also amplified Western mosquitofish (*Gambusia affinis*, tissue and environmental DNA extracts). This lack of specificity led us to develop and test new primer sets for dace and red swamp crayfish. Calibrations of the new primers, using tissue (fin clips), timed microcosm tests, and environmental sampling support a high level of sensitivity (~1 individual in 100,000 L of water) and specificity for Moapa dace and mosquitofish. Detection of red swamp crayfish was also improved through primer optimization. A watershed-scale eDNA survey for Moapa dace was conducted in parallel with a traditional snorkel survey in the headwaters of the Muddy River. eDNA analysis was still underway at the time of abstract submission and results will be presented in the session. The results from this preliminary study support qPCR-based eDNA monitoring as a cost-effective and high-sensitivity approach for the periodic surveillance of both endemic fishes and potential invaders in desert aquatic ecosystems.

10:45-11:00: *Herichthys cyanoguttatus* high-quality genome & genome level introgression into *H. minckleyi* – **Darrin Hulsey**

I will discuss the completion of the high-quality genome of the Texas Cichlid (*H. cyanoguttatus*) and its use investigating *H. minckleyi* in the Cuatro Ciénegas basin. Genome resequencing of 100 *H. minckleyi* highlight both the geographical regions of the basin showing highest levels of introgression and which parts of the *H. minckleyi* genome show substantial introgression.

11:00-11:15: Building Collections to Support Conservation Genomics of Desert Fishes – **Thomas Turner & Emily DeArmon**

Enormous progress has been made in expanding the utility of genomics for conservation biology. Yet, to fully realize its potential, the community needs access to samples that are sufficiently replicated in time and space to permit robust hypothesis tests and monitoring with statistical confidence. We present a collective effort to build genomic resources and specimen-rich tissue archives for imperiled fishes of the American southwest through extensive partnerships with researchers, management agencies, and NGOs. Genome projects and high-throughput genetic screening tools are under development for eight species that have been

systematically monitored for decades. Corresponding tissue archives bracket major environmental disturbances like drought and mega-wildfire and are valuable for understanding demographic responses and impacts of recovery actions. We evaluate logistical and practical trade-offs to archive design, including cost, assay breadth, efficiency, and long-term stability of archived tissue samples. From this analysis, we develop a tissue deposition strategy that encompasses a variety of applications from long-read whole genome sequencing to rapid genotype by sequencing and RADseq approaches. Because the Museum of Southwestern Biology is a project-driven collection with a regional focus, we are well suited to develop and curate this critical archive that can inform future management actions as climate change transforms aquatic ecosystems in the southwestern US.

11:15-11:30: Ammonia as a tool for removal of invasive crayfish – **Susan Wood & David Ward**

Among the most destructive of aquatic invasives are multiple species of crayfish, several of which have been introduced globally. Across the southwestern US, introduced crayfish have negatively impacted native species due to their opportunistic feeding habits and ability to travel between isolated aquatic systems. Efforts to manually remove crayfish from invaded habitats have met with limited success. With increasing numbers of invasive species in aquatic systems comes a growing need for additional removal methods. The use of ammonia has shown promise as an alternative chemical removal technique for invasive fish. An ammonia-based tool could be a cost-effective way to eradicate invasive crayfish and support conservation of native aquatic species while utilizing natural nitrogen cycling to return an ecosystem to baseline conditions. To evaluate the use of ammonia as a tool for controlling invasive crayfish, specifically Northern Crayfish (*Faxonius virilis*) and Red Swamp Crayfish (*Procambarus clarkii*), we have used laboratory experiments to quantify lethal concentrations. Preliminary trials indicate that doses lethal to fish (21mg/l Total Ammonia Nitrogen (TAN) at a pH over 8) are ineffective in causing mortality for *F. virilis*. Concentrations approaching 50 mg/l TAN at a pH over 9.5 will kill crayfish if dissolved oxygen levels are also lowered using sodium sulfite. This combination of ammonium sulfate, sodium sulfite, and sodium carbonate to increase pH, achieves 100% mortality of *F. virilis* in 24 hours in a laboratory setting. Additional laboratory trials with *P. clarkii*, as well as field trials for both species, will be conducted to further investigate the potential for ammonia as a crayfish removal and management tool.

11:30-11:45: Existing Aridity Gradient Mirrors Future Fish Assemblage Projections Under Climate Change Scenarios – **Joshuah Perkin, Lindsey Elkins, Rebecca Mangold, Mariana Perez Rocha, Astrid Schwalb, Ben Schwartz, Weston Nowlin, Karl Cottenie, Christina Saltus, Richard Johansen, & David Smith**

Anthropogenically-driven climate change combined with existing ecosystem degradation is projected to cause future losses of global freshwater biodiversity, particularly in arid and semi-arid areas within temperate climate regions. It is therefore necessary to understand both contemporary drivers of freshwater biodiversity loss as well as how future climatic conditions might affect humans and nature. For example, within aquatic ecosystems, streamflow and thermal regimes are fundamental regulators of ecosystem properties, but both are expected to

change in response to climate change. Analysis of existing environmental gradients has the potential to aid in projecting climatic influences on a variety of organisms; however, few analyses have focused on freshwater fish assemblages. We present a multi-scale, spatiotemporal approach to predictive ecological modelling that ultimately demonstrates that an existing aridity gradient is a suitable proxy for freshwater fish assemblage response to climate change projections for the same region. We conducted our study using fish collections from 100 sampling reaches distributed across the central Colorado River basin of Texas. We combined fish assemblage surveys, local habitat characteristics, and remotely sensed geospatial riverscape data to (1) analyze spatial variation in fish-environment relationships under current conditions, and (2) used climate change projections for air temperature and precipitation to predict shifts in fish assemblage structure under multiple emissions scenarios. Our results revealed that spatial shifts in fish assemblage structure along an existing aridity gradient mirrored the modelled assemblage-level shifts under climate change projections for the emissions scenarios (or "Representative Concentration Pathways") 4.5 and 8.5 projected through 2100. The model predicts a general shift towards invasive, warm-water assemblages and the potential loss of endemic, cool-water-dependent species. Our framework underscores the importance of multiscale, spatiotemporal modelling approaches that consider multiple dimensions of the total environment while assessing patterns and predictors of ecological change.

11:45-12:00:

Scratching the surface: A preview of imagery of ongoing desert fish film & photo projects from Freshwaters Illustrated – **Jeremy Monroe & David Herasimtschuk**

An update on several ongoing film and photo projects on desert fish, aquatic biodiversity, and water stories from the Colorado River system and Great Basin. This presentation will share previews of imagery of imperiled fishes and aquatic life from rivers and spring systems, along with conservation work of partners from DFHP, DFC, USFWS, US Forest Service, NPS, NDOW, Navajo Nation, USGS, and others.

12:00-13:30: **LUNCH**

SATURDAY AFTERNOON, NOVEMBER 19 – MAIN CONFERENCE ROOM

General Session – Moderator Michael Schwemm

13:30-13:45: Climate Change & Managing Effects of Increasing Wildfires on Southwestern Fishes – **Scott Bonar**

The largest wildfires in the State of Arizona have occurred since the start of the 21st century, related to ever increasing greenhouse gas concentrations in the atmosphere, climate change and resulting droughts. Wildfires can be particularly impactful in watersheds containing rare species. To be successful, biologists must become increasingly familiar with effects of these events on Southwestern fishes. Fishes can be affected during the fire itself, and following the fire through debris flows, removal of riparian canopies and other factors that affect stream temperatures and water quality. Temperature tolerances of desert fishes are not as high as one might expect; and reproduction of many species can be affected by changes in temperature, flow and substrate. Adaptation methods include preparing watersheds to reduce fire impact and debris flows; removing fish in advance of fires and then repatriating them later; restoring damaged canopies with plant species that provide the most shade and cooling potential. Mitigation methods include a strong education component on the effects of greenhouse gas emissions on climate change, resulting drought and associated fires. Here I show interactions that our lab has had with wildfires in the Southwest, selected research conducted, and experiences we have had over the last 20 years that can help inform fish/fire management.

13:45-14:00: Results from radio-telemetry of captively reared desert suckers in Upper Klamath Lake – **Josh Rasmussen, Christie Nichols & Evan Childress**

Since 2016, the U.S. Fish and Wildlife Service (USFWS) has been rearing wild caught larvae to grow to ~200 mm in the Klamath Falls National Fish Hatchery and captive rearing facility, a priority recovery action listed in C'Waam, or Lost River sucker (*Deltistes luxatus*) and Koptu, or Shortnose sucker (*Chasmistes brevirostrus*) recovery plan. This program is known as the Sucker Assisted Rearing Program (SARP), and plans include stocking fish twice-annually in spring and fall, at varying sizes, and at several different locations in Upper Klamath Lake and tributaries. The radio-tagged fish consist of a subset of the stocked fish and will follow the protocols of stocking that are laid out by the SARP program and managers.

To determine the fate of the released fish and assist with management of this rearing effort, USFWS has conducted several iterations of radio telemetry and plans to continue tracking released fish. The first effort of radio telemetry of SARP fish occurred in 2018 and 2019. This effort utilized a combination of boat and plane tracking using radio tags that were equipped with a mortality indicator. In 2021, USFWS continued this effort and added additional aerial surveys and lakeside remote stations. Additionally, acoustic tag technology was assessed for use in this system.

Little data exists for juvenile Lost River and shortnose sucker because few fish are collected in the wild annually and there is little to no survival of juveniles to recruit into the spawning population. Given this, information about habitat use by this life stage is lacking, but it is largely assumed that wetland habitat is important for nursery and rearing of these species. This data is some of the first to show an affinity for wetland margin habitat for this life stage. A majority of fish from both stocked fish cohorts were re-detected after being stocked into Upper Klamath

Lake. There was no significant difference in survival based on stocking location or size at stocking. However, fish with greater "condition" (heavier than predicted weight at given length) experienced greater survival. Given the ongoing data acquisition of location and survival data, we are gaining a better understanding of rearing management and areas in the lake that need to be protected, restored, and monitored for potential future juvenile recruitment.

14:00-14:15: Longer day length may maximize larval growth in captive Devils Hole pupfish but are there physiological costs? – **Jennifer Gumm & Olin Feuerbacher**

Artificial light at night (ALAN) is a form of anthropogenic pollution that alters the natural light and dark cycle in an ecosystem. ALAN can affect circadian and circannual rhythms, physiology and behavior. ALAN affects the photoperiod across life history stages, including reproduction, growth, development, and activity in aquatic organisms. Many qualities of light availability may influence fish in captivity and should be considered in the context of aquaculture methods. Photoperiod or daylength and light intensity are the most well studied aspects of light availability in the context of aquaculture. Of particular interest is the feeding response of larval fish in response to different light conditions. In many species, longer daylengths interact with food availability to maximize growth, however, the response to ALAN on fish physiology including the endocrine stress response, is often unknown. Here, we test the response of endangered Devils Hole pupfish (*Cyprinodon diabolis*) to ALAN, by measuring cortisol release rates, as well as testing response to an acute stressor. We used non-invasive water-borne hormone method to measure cortisol release rates before and two weeks after moving fish out of ALAN exposure. Cortisol release rates over an hour were very high so in the future we can test fish over 30 min. We found that there was no significant difference in cortisol production after a change in ALAN, suggesting that the benefit of maximizing growth may not come at a physiological cost. Fish also showed a significant increase in cortisol release rates to an acute stressor, indicating that captive Devils Hole pupfish have a healthy HPI axis. Future studies examining the role of hormones in reproduction, growth and development can now be pursued in this small, endangered fish using this non-invasive method.

14:15-14:30: Advances in captive rearing of Devils Hole pupfish at the Ash Meadows Fish Conservation Facility – **Olin Feuerbacher, Jennifer Gumm, Kevin Wilson, Ambre Chaudoin, Jeffrey Goldstein, Alex Jones, Michael Schwemm, John Wullschleger, Corey Lee, & Brandon Senger**

The Ash Meadows Fish Conservation Facility began operation in 2013, primarily intended to develop a lifeboat population of Devils Hole Pupfish, *Cyprinodon diabolis*. Since the initial stocking of the 100,000-gallon refuge tank with 29 individuals in 2014, the population has grown to over 300 fish. Monthly collection of eggs from Devils Hole augments the population and provides gene flow into the captive population. Egg collections from the refuge tank have allowed for laboratory experimentation and breeding trials to refine captive rearing methods. This experimentation has provided insights into disease burden, fecundity, and egg viability, as well as hatch, survival, and growth rates. Comparison of data from fish reared from eggs produced in Devils Hole, the refuge tank, and aquaria have shown differences between the

populations, particularly in egg viability and subsequent hatch and survival rates. Lower egg viability and increased rates of embryo malformations from fish in aquaria led to the development of new rearing methods and customized foods for broodstock.

14:30-14:45: Obituary for Héctor Espinosa – **Dean Hendrickson, Alejandro Varela-Romero, Lloyd Findley**

Long-time DFC member and participant in many meetings, Héctor Espinosa Pérez, died in Mexico City on February 20th, 2022, a few days after his 68th birthday.

Many DFC members knew him quite well and might remember his generous sharing of tequilas (for many years he brought it in bottles that carried his own special private label) in get-togethers in hotel rooms after the paper sessions. Over his career Héctor made it to at least 162 meetings (90 in México, 72 international)! Nineteen of those were DFC meetings (10 in the US, 9 in México). Almost all of his absences at DFC corresponded to date conflicts with meetings of both the Mexican Ichthyology Society (SIMAC), in which he was an officer (including President), and the Latinomamerican Ichthyology Congress, in which he was also active. At those 19 DFC meetings, he was presenter or co-author on > 24 papers (there are no data available for the 2018 50th anniversary meeting, but he was present). At DFC's 2010 meeting, his student, and later Collection Manager, Christian Lambarri, was awarded DFC's Robert Rush and Frances Hubbs Miller prize for the best paper presented by a student from a Latin American country for her first-ever, sole-authored paper. Héctor's wife, Patricia Fuentes-Mata, a fisheries biologist for the National Fisheries Commission (CONAPESCA) also was a presenter and/or co-author on several papers at DFC, and Patty and their two sons, Alex and Héctor, accompanied Héctor to many DFC meetings. At the time he became ill, Héctor was working to arrange another meeting of the DFC in Cuatro Ciénegas, but both the global pandemic and his illness thwarted that.

Héctor completed his B.S. in Biology at Universidad Nacional Autónoma de México (UNAM) in 1985 and continued there for an M.Sc. and continued there as a professor and curator of México's National Fish Collection. Over his career, Héctor published 68 scientific articles, 43 book chapters, and seven books, in addition to several popular texts, which have been cited about 3000 times from 1988 to present. He also was a founder and President of SIMAC, the Mexican Ichthyology Society, and was present at probably as many (if not more) meetings of the American Society of Ichthyologists and Herpetologists as DFC meetings. He was long a member of the ASIH-AFS Committee on the Common and Scientific Names of Fishes of the United States, Canada and Mexico, and he worked diligently with that committee on the new version of that huge project (now in final editing with the publisher) until very close to his passing.

On October 6 of this year, the Instituto de Biología de la UNAM in Mexico City hosted a moving homage to Héctor, all 4 hours of which were recorded and archived on UNAM's YouTube Channel. A specially commissioned painting of Héctor alongside his favorite poza in Cuatro Ciénegas was given to the family at that event, and a plaque honoring him was unveiled before its installation in a prominent place in the University's brand new and beautiful public Biodiversity Museum and Collections facility, into which the Fish (and other) Biodiversity Collections are currently moving. Héctor was involved in preparing for the move, and I'm sure will rejoice, wherever he is, when the move into this much-improved space is finally completed.

Héctor's contributions and conviviality will be sorely missed by DFC and many other widely scattered collaborators and friends. I've brought tequila to this meeting in his honor, and invite you to share it with all interested in a toast to Héctor. ¡Salud Hectorcito!

14:45-15:00: **BREAK**

General Session – Moderator Kate Boersma

15:00-15:15: Analysis of the movement & home range of the Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*) in the Sonoyta River, Sonora, Mexico – **Miguel Angel Grageda Garcia & Michael T. Bogan**

For this study, the movements, home range, and activity of the Sonoyta short-breasted turtle (*Kinosternon sonoriense longifemorale*) were quantified in two sites within the Sonoyta River, Sonora, Mexico. The technique used to collect data was radiotelemetry. The first site within the area of study is called Agua Dulce reach, where 23 turtles were tracked over a four-year period. The second site is known as the Morelia site where 9 turtles were tracked over one year. The turtles in the Morelia section were specimens rescued from a dry sewage lagoon located 3km from the site in the town of Sonoyta, which were subsequently moved and released into the Sonoyta River. The movement and activity patterns of the turtles depended on the availability of water and varied according to their sex and size. Although the Sonoyta mud turtle is considered almost entirely as an aquatic reptile. It has been recorded aestivating on land during periods of extreme drought. Adult male tortoises at the Agua Dulce site made longer movements (Average Daily Distance (Add) = 4.62 m + 3.71) and had a larger home range area (3.7 ha) than adult females (Add = 2.3 m + 2.25; surface = 3.25 ha). Meanwhile, adult male turtles in Morelia also had longer movements (Add = 8.06 m + 3.68) and had a larger home range area (3.92 ha) than adult females (Add = 3.19 + 2.34; = 2.69 ha). No turtles were found outside the boundaries of the study site. Degradation and loss of water in the Sonoyta River can lead to the decline or disappearance of the available habitat of the Sonoyta mud turtle and its population.

15:15-15:30: Unexpected distribution of aquatic invertebrate communities in a threatened desert wetland: Sentenac Cienega, Anza-Borrego Desert State Park, CA – **Kate Boersma, Rainier Cardin, Janelle Doi & Jessica Cidrao**

Sentenac Cienega is a wetland in the Colorado Desert of Southern California that has experienced rapid drying over the past two decades and now holds surface water for only a few months per year. The Cienega is in the headwaters of the San Felipe Creek watershed and forms a transition point between perennial reaches upstream and non-perennial reaches downstream. As such, the wetland may be an important dispersal corridor for flying aquatic invertebrates moving downstream to colonize temporary aquatic habitats. Here we report the results of: 1) a four-year field study comparing aquatic invertebrate communities upstream and downstream of the wetland, and 2) a mesocosm experiment measuring invertebrate colonization of novel downstream habitats. Overall, we found very little overlap in invertebrate community composition between perennial and non-perennial stream reaches, even among sites located

within 1km of each other. Additionally, in the mesocosm experiment, taxa from perennial reaches rarely colonized novel artificial habitats downstream. Sentenac Cienega appears to act as a dispersal barrier instead of a dispersal corridor as predicted, which contradicts expectations based on prior research in nearby streams. It is likely that unique local conditions in the San Felipe Creek watershed, such as anthropogenic influences and complex groundwater dynamics, contribute to the unexpected distribution of aquatic invertebrates that we observed. Our data will inform an ongoing collaboration with hydrologists, cultural anthropologists, terrestrial ecologists, and land managers to develop a restoration plan to protect the future of this biologically and culturally important area.

15:30-15:45: Integrative Taxonomic Investigation of *Cyprinella* sp. Nueces, a Putative Undescribed Species of Greatest Conservation Need in Texas – **Kevin Conway, Kole Kubicek, Luke Bower, Evan Carson, Amanda Pinion, Elizabeth Hunt, & David Portnoy**

The Plateau Shiner (*Cyprinella lepida* Girard, 1856) is endemic to the upper reaches of the Nueces River drainage in TX. Previous genetic investigations of *Cyprinella lepida* revealed two divergent and geographically isolated groups based on mtDNA, including a group restricted to the upper Frio and Sabinal rivers (referred to as *C*. *lepida*) and a group restricted to the upper Nueces River, and more closely related to *C*. *lutrensis* than *C*. *lepida*. This later group has been referred to as either *C*. sp. cf. *lepida* or *C*. sp. Nueces, and is hypothesized to be the product of an ancient hybridization event between the historical upper Nueces River population of *C*. *lepida* and a lineage resembling *C*. *lutrensis*, resulting in introgression and replacement of ancestral *C.* lepida mtDNA in upper Nueces River. In addition to differences in mtDNA, *C*. *lepida* (Frio/Sabinal) and *C*. sp. Nueces (Nueces) also are reported to exhibit differences in color pattern, and the question of whether to recognize *C*. sp. Nueces as a distinct species has been raised on multiple occasions. Though no formal taxonomic conclusions have been published on the validity of *C*. sp. Nueces, this "putative" species has recently been listed as a Species of Greatest Conservation Need (SGCN) in Texas. We use a combination of qualitative osteological characters, traditional meristic characters (e.g., numbers of fin rays, scales and vertebrae) and landmark-based geometric morphometric characters to assess whether differences in morphology and body shape exist between *C*. *lepida* and *C*. sp. Nueces. We also, and for the first time, investigate if there are significant differences in the nuclear genome of *C*. *lepida* and *C.* sp. Nueces by comparing hundreds of nuclear loci obtained using double digest restriction-site associated sequencing (ddRAD-seq). We discuss our findings in relation to the question: should *C*. sp. Nueces be recognized as a distinct species?

15:45-16:00: An epoch abroad: how & when *Cyprinodon* may have reached the Great Basin (& points along the way) – **Christopher Hoagstrom & Megan Osborne**

Most native fishes of the Colorado River drainage are evolutionary affiliated with rivers of the Pacific Coast. Genus *Cyprinodon* is an exception, affiliated instead with the Gulf of México. In the Late Miocene, this genus produced five western mitochondrial lineages in relative synchrony. Four of these have clear affiliations with Late Miocene drainages then tributary to the Gulf of México. A fifth (western clade) occupies the Río Grande Rift, lower Colorado River drainage, and

adjacent Southern Great Basin, but has no clear route from the Gulf of México to these regions. Although present in several other *Cyprinodon* clades, the western clade shows no evidence of secondary contact with other clades, consistent with a hypothesis that it remained isolated after its origin. Geomorphic evidence suggests a possible Late Miocene route into the nascent Río Grande Rift (Albuquerque Basin) from an area of widespread dissolution subsidence on the southern High Plains. From there, an isolated founder population could have expanded in distribution downstream as the upper Río Grande expanded southward along the rift. Populations in the southern rift potentially had westward access through the Cochise Filter Barrier via a series of closed basins that held warmwater lakes in the middle Pliocene. A possible route into the Safford Basin could have established the clade in the Colorado River drainage, allowing colonization of Gila River and Lower Colorado River, along the eastern boundary of the Southern Great Basin. Divergence estimates for the above evolutionary events correspond with timings of potential access based on geological and environmental evidence, but more focused study is needed to better support or refute each event.

16:00-16:15: Farewell 2022 – Kevin Wilson, President

SUNDAY MORNING, NOVEMBER 20

09:00-12:00: Virgin River Field Trip