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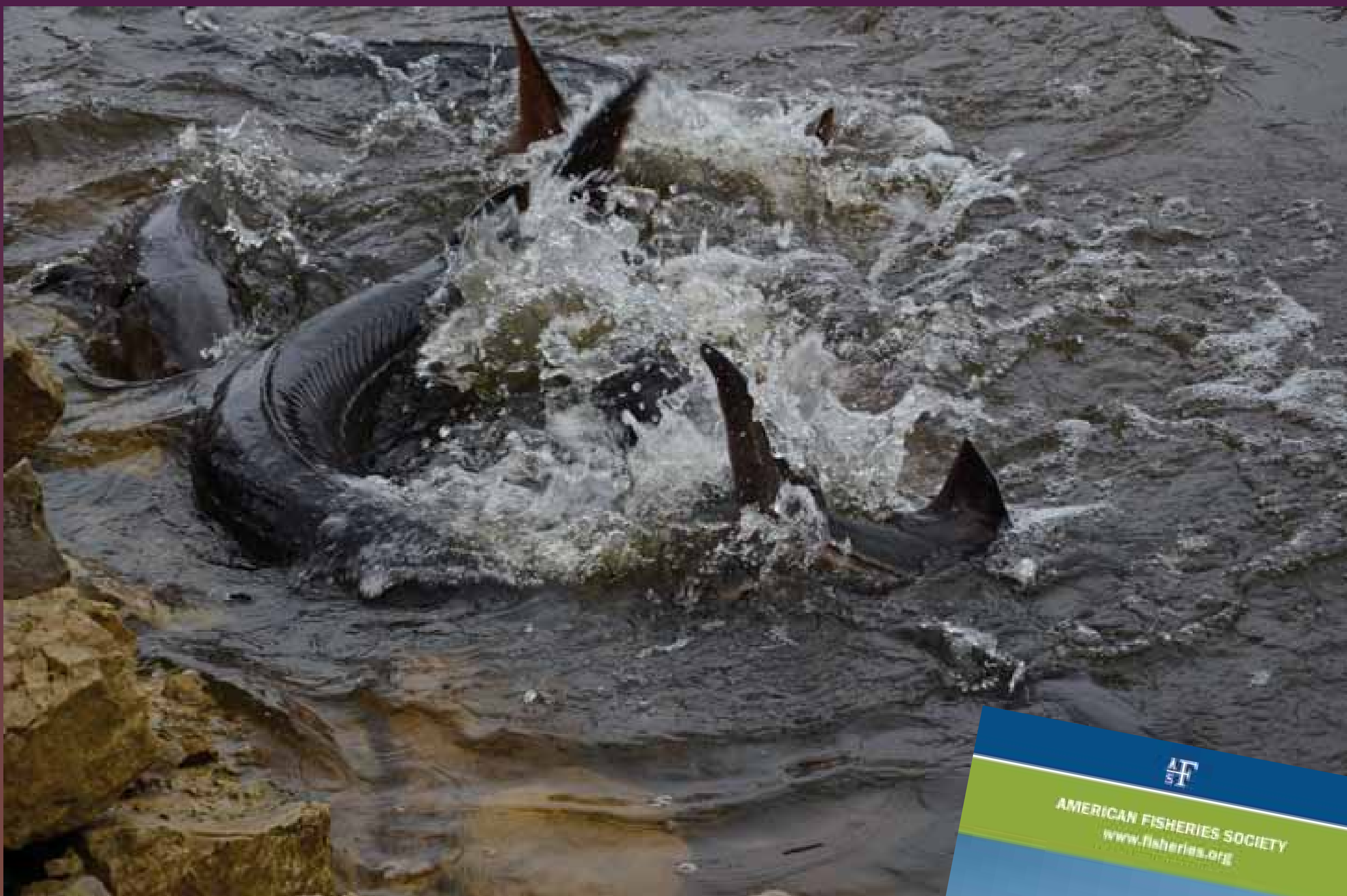

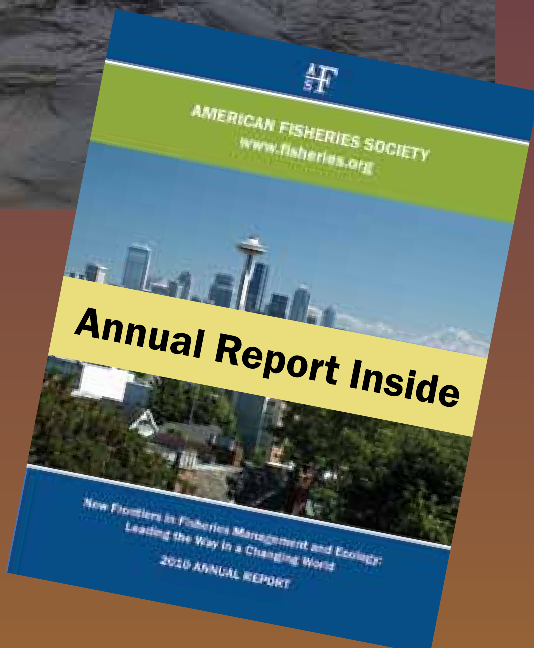

Stream Fragmentation Thresholds for a Reproductive Guild of Great Plains Fishes

Contrasting Global Game Fish and Non-Game Fish Species

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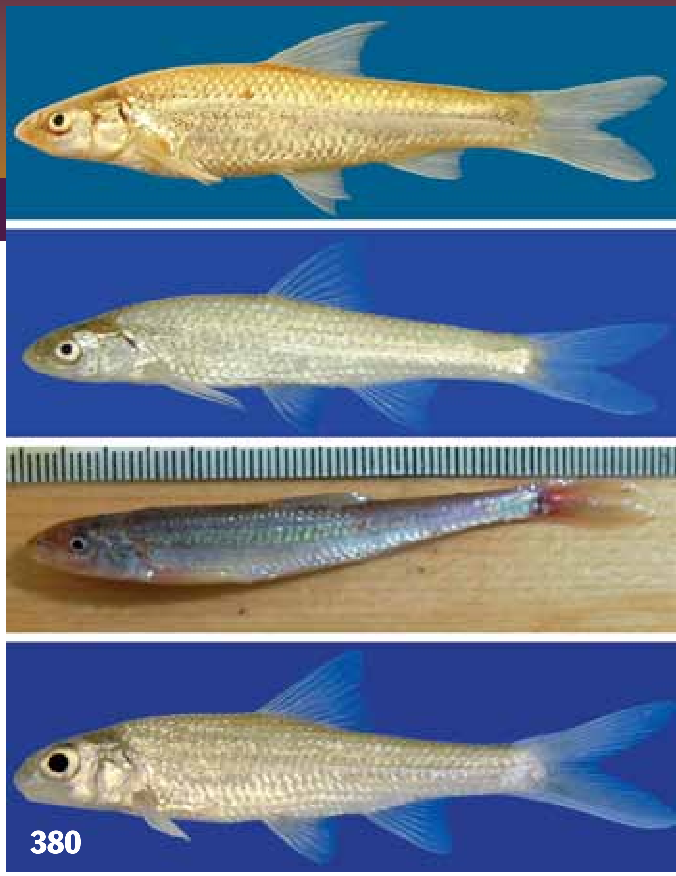

Great Plains cyprinids suspected or confirmed as members of the pelagic-spawning reproductive guild.

COVER: Photo of spawning sturgeon taken on the Wolf River, near New London, Wisconsin. April, 2011.
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EDITORIAL / SUBSCRIPTION / CIRCULATION OFFICES
5410 Grosvenor Lane, Suite 110 • Bethesda, MD 20814-2199
(301) 897-8616 • fax (301)897-8096 • main@fisheries.org

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Column: PRESIDENT'S HOOK

New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World

Wayne A. Hubert, President

AFS President Hubert may be contacted at: WHubert@uwyo.edu

This title has been the theme for the past year. The intent was to challenge our thinking about trends in our field and how the American Fisheries Society (AFS) and its members will serve as leaders in this changing world. We all know that we have tremendous challenges ahead and we are aware of many of them. Jared Diamond (2005) wrote a compelling book, *Collapse. How Societies Choose to Fail or Succeed*, in which he describes the collapse of several ancient cultures largely because of their inability to collaborate and address the overconsumption of natural resources. The potential exists for collapse of human society as we know it today if we continue unabated to burn fossil fuels; destroy forests, grasslands, estuaries, and coastal areas; pollute waters; enhance urban sprawl; deplete croplands; harvest renewable resources at a faster rate than they can be replenished; and vastly alter ecological processes on which we depend. At times I fear for my grandchildren and what they will encounter as they grow into adults and produce another generation. But, most of the time, I am optimistic that this modern world will merge science and politics to address environmental problems in serious ways. I believe that it will be organizations such as the American Fisheries Society that will emerge to lead the way.

Throughout the past year, many, many people have contributed to our Society with the intent of achieving our mission. In this "President's Hook" I have taken on a challenge at which I know I am going to fail. I want to acknowledge everyone who has contributed to the Society and its mission over the year, but I know that is impossible. Nonetheless, I will acknowledge the tremendous contributions of many key players and tell those who I have failed to mention that your efforts are deeply appreciated and not at all diminished by my shortfalls.

Our 141st annual meeting in Seattle addresses the theme for the year with over 90 symposia, the largest number ever at one of our meetings. Additionally, there are hundreds of contributed papers and posters addressing contemporary issues in the fisheries sciences. The Local Arrangements Committee cochairs, **Cleve Steward** and **Larry Dominguez**, and the Program Committee cochairs, **Craig Busack** and **Dave Ward**, along with all of their subcommittee chairs, subcommittee members, and associated volunteers, pulled together to make this an outstanding meeting, identifying the new frontiers in fisheries management and ecology and providing insight as to how to lead in a changing world. It has been a 4-year effort to bring the annual meeting to fruition. I am amazed by and extremely grateful to all who made it happen.

Our **governing board** is composed of the five elected officers of the Society, the president and vice president of each of the four divisions, and the president of each of the sections. That is a huge group that works together to achieve the goals of the Society and establish strategy into the future. I have been amazed by the collegial, dedicated array of professionals who serve on this body. I thank them for their diligence and, particularly, for enabling our business to be conducted in a focused and orderly manner. With the help of our constitutional consultant, **Ira Adelman**, they made my job of chairing meetings and conducting business a real pleasure. My fellow officers, **Bill Fisher**, president elect; **John Boreman**, first vice president; **Bob Hughes**, second vice president; and **Don Jackson**, past president, provided guidance and counsel and carried much of the load throughout the year. To them I am extremely thankful.

Much of the real work conducted by the Society is done by about 25 standing committees, with over 300 AFS members serving on these committees each year. They are all volunteers, all contributing their "spare" time. Each year the president appoints chairs for the standing committees and works with the chairs to appoint members. That is probably the biggest task that the president carries out as the "workhorses" are recruited and charged with their duties. Space does not allow me to mention all of the members of committees, but I feel compelled to identify the committees and their chairs and extend my sincere appreciation to the chairs and all the committee members for their dedication and hard work on behalf of the Society.

The Board of Professional Certification was chaired by **Barry Smith**. He guided the chairs of three subcommittees (**Michael Brown**, **Lil Herger**, and himself), and worked closely with AFS staff (**Gail Goldberg**) to assess certified fisheries professional applications. They handled several dozen during the year. What a task!

All continuing education courses offered by the Society and carrying continuing education credit pertinent to the Professional Certification Program must be approved by the Continuing Education Committee, which was chaired by **Dan Dauwalter**. This committee of over a dozen members worked diligently to assess and approve a large number of courses, many offered in conjunction with the 2011 annual meeting. This year, a special subcommittee chaired by **Melissa Wuellner** developed strategies for providing distance learning options

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Elden W. Hawkes, Jr.

Policy Coordinator Hawkes can be contacted at ehawkes@fisheries.org

Proposed Budget Cuts For FY 2012: Non-Governmental Organizations Talk About the Future of the State and Tribal Wildlife Grants Program

Representatives from the American Fisheries Society, the Association of Fish and Wildlife Agencies, The Wildlife Society, and The Nature Conservancy met recently to express the importance of continued funding of the State and Tribal Wildlife grants program for the Fiscal Year 2012 budget to staffers representing Senators Reed (RI) and Murkowski (AK). While understanding that the program will not be restored back to FY 2010 funding levels, the contingent stressed how vital the grants were to state conservation programs. The group highlighted many vital uses of the program, including that many states use the State and Tribal Wildlife grants to fund co-op work with other conservation agencies, and that the U.S. Fish and Wildlife Service relies on the program to facilitate many endangered species recovery programs. The contingent further stressed that continuing to fund the grants will save taxpayers money because they are keeping species from being listed.

The representatives of Senators Reed and Murkowski indicated that it is going to be tough to keep funding levels as they are. They indicated that the FY 2012 budget may take the form of continuing resolutions which would maintain proportional across the board cuts, but much of what happens has to do with any agreement that comes out of the debt ceiling talks. They also indicated that there are talks to make the grants more competitive than they already are.

Overall, the staffers stated that their senators were in full support of the program, but that they needed Non-Governmental Organizations (NGOs) to get the word out about all the good work that the grants were enabling. They stressed that NGOs needed to show that the grant programs do get animals off of the endangered species list, and that it is the responsibility of federal government to fund these grants. More importantly the work that the grants fund helps to prevent more regulations from being enacted in the future.

Federal Interagency Council to Promote Outdoor Recreation

As part of the America's Great Outdoors Initiative, the Department of the Interior, Department of Agriculture, Department of the Army, Department of Commerce, and the White House Council on Environmental Quality signed a Memorandum of Understanding to establish the Federal Interagency Council on Outdoor Recreation (FICOR).

The purpose of the FICOR is to:

- Coordinate recreation management, access policies across multiple agencies to improve public enjoyment and recreational use of federal lands;
- Provide the public with reliable and up-to-date web-based information on outdoor recreation that is easily accessible with modern communication devices; and to evolve and promote the federal interagency www.recreation.gov website to become a one-stop portal for information and resources about federal and federally supported outdoor recreation opportunities, locations, permit and reservation requirements, access, routes, features, and transportation options;
- Streamline and align policies and procedures among federal, state, local, tribal, and other outdoor recreation providers;
- Improve engagement of young people and their families in outdoor recreation through healthy, active lifestyles;
- Target underserved and disadvantaged communities for both access and engagement in the benefits of and opportunities for outdoor recreation;
- Identify ways to improve access to and benefits from our parks, refuges, and other public lands, waters, and shores for persons with disabilities; and
- Identify partners outside the federal government who can promote outdoor recreation and provide additional resources and access.

The new council will work closely to coordinate and promote outdoor recreation opportunities on public lands in partnership with federal, state, and tribal agencies.

Stream Fragmentation Thresholds for a Reproductive Guild of Great Plains Fishes

Joshuah S. Perkin

Doctoral candidate, Division of Biology, Kansas State University, 116 Ackert Hall, Manhattan, KS 66506. E-mail: jperkin@ksu.edu

Keith B. Gido

Associate Professor, Division of Biology, Kansas State University, 116 Ackert Hall, Manhattan, KS 66506

ABSTRACT: Impoundments, diversion dams, and stream dewatering have created a mosaic of large river fragments throughout the Great Plains of central North America. Coincident with these habitat changes are massive declines in the distribution and abundance of Great Plains fishes belonging to the "pelagic-spawning" reproductive guild. We analyzed longitudinal fragment lengths (measured in river kilometers, rkm) and literature accounts of population status for eight species from this guild across 60 fragments to derive thresholds in stream length associated with extirpations. Fragment length predicted population status ($F_{2,21} = 30.14$, $P < 0.01$), with lengths averaging 136 ± 21 rkm for extirpated, 226 ± 69 rkm for declining, and 458 ± 137 for stable populations. Fragment length explained 71% of reported extirpations and estimated thresholds in fragment length explained 67% of variation in population persistence. Our findings provide insight into appropriate spatial scales for conducting riverscape conservation approaches that address the hierarchical effects of fragmentation on stream-dwelling fishes.

Límites de fragmentación fluvial para un gremio reproductivo de peces de las grandes planicies de Norteamérica

RESUMEN: los embalses, presas de derivación y la desviación de caudales han generado un mosaico de fragmentación de los ríos a lo largo de las grandes planicies de la porción central de Norteamérica. De forma paralela a estos cambios, en la región se tienen disminuciones generalizadas en la abundancia y distribución de peces que pertenecen al gremio reproductivo de desovadores pelágicos. Se analizó la dimensión de los fragmentos observados (medida en km de río) y literatura disponible sobre el estado de las poblaciones de ocho especies de dicho gremio, con el fin de determinar medidas límites en la longitud de dichos fragmentos que se encuentran asociados a la extirpación de las poblaciones. La longitud de los fragmentos fue un buen predictor del estado de la población (F2,21 = 30.14, P < 0.01) con longitudes promedio de 136 ±21 rkm para las extirpadas, 226 ±69 rkm para las que se encuentran en declive y 458 ±137 para las poblaciones estables. La longitud de los fragmentos explicó el 70% de las extirpaciones reportadas y los valores límites de longitud del fragmento explicaron 67% de la variación en la persistencia de las poblaciones. Estos resultados proveen información sobre las escalas espaciales que deben considerar las medidas de conservación de los paisajes fluviales para atender los efectos jerárquicos que la fragmentación tiene sobre los peces demersales de río.

Introduction

Humans have altered biological and ecological processes and influenced the abundance and distribution of organisms on a global scale (Dudgeon et al. 2006; Vorosmarty et al. 2010). In particular, groundwater depletion and impoundment of surface waters have compromised the connectivity of many freshwater ecosystems, constraining the ability of stream organisms to use these habitats (Nilsson et al. 2005). These alterations have imperiled freshwater organisms worldwide, most notably organisms dependent upon streams and rivers for long-term persistence (Lytle and Poff 2004; Nilsson et al. 2005). Although the importance of preserving entire riverscapes has recently been recognized as a viable conservation strategy (Fausch et al. 2002), there is limited information on the spatial scale necessary to preserve biodiversity in lotic systems.

Within the coterminous United States, 85% of large rivers are fragmented by impoundments that divide streams longitudinally, alter flow regimes, and reduce transport of sediments (Hughes et al. 2005). Extensive stream fragmentation, combined with other anthropogenic disturbances (e.g., degradation of water quality, introduction of nonnative species), contributes to the imperiled status of nearly 40% of North American freshwater and diadromous fishes (Jelks et al. 2008). Among these imperiled fishes, small-bodied minnows (family Cyprinidae) that dispense passively drifting eggs and larvae into large flowing streams have declined during the past 60 years. These pelagic-spawning fishes decline in association with human alterations to streams, specifically stream fragmentation (Platania and Altenbach 1998; Luttrell et al. 1999). For example, peppered chub (*Macrhybopsis tetranema*) is now extirpated from 90% of its historical range and persists in only two isolated Arkansas River Basin fragments separated by more than 400 km (Luttrell et al. 1999). Similarly, the federally threatened Arkansas River shiner (*Notropis girardi*) is now extirpated from 80% of its historical range and is currently found in only two isolated fragments of the Arkansas River Basin (Wilde 2002). Documented extirpations of these and other pelagic-spawning cyprinid species coincide with a period of extensive fragmentation of North American rivers from 1950 to 1970 (Cross et al. 1985; Luttrell et al. 1999; Gido et al. 2010).

Reduced stream connectivity is particularly detrimental to pelagic-spawning fishes because of their unique reproductive ecology; for example, pelagic-spawning cyprinids dispense gametes into pelagic zones of flowing streams. Immediately following spawning, water enters cell membranes osmotically and causes eggs to swell and become semibuoyant (in physical terms, slightly negatively buoyant; Bottrell et al. 1964). These semibuoyant eggs remain suspended within the water column at current velocities above 0.01 m/s, drift for 24–28 h before hatching, and then drift for an additional 2–3 days as developing larvae. During the drift period, individuals presumably become displaced great distances downstream (>140 km) from parent localities before complete development of a gas bladder and the onset of exogenous feeding, which allow larval individuals to exit the drift (Moore 1944; Platania and Altenbach 1998). The extent to which larval individuals continue to drift is largely unknown (Durham and Wilde 2008). Consequently, large river fragments (>100 km) are required by drifting eggs and larvae (collectively referred to as "ichthyoplankton"; *sensu* Dudley and Platania 2007) to allow time to develop before being deposited in impounded downstream habitats. Downstream transport is of particular concern because high mortality rates occur among ichthyoplankton deposited within downstream reservoirs, due to suffocation within anoxic sediments or predation from lacustrine species (Platania and Altenbach 1998; Dudley and Platania 2007; Pompeu et al. in press). Spatial dynamics of adult pelagic-spawning cyprinids also are disrupted by stream fragmentation (Luttrell et al. 1999; Bonner 2000). During adult stages, some pelagic-spawning cyprinids are capable of moving upstream on the order of 50 km in less than 72 h (Bestgen et al. 2010) and are presumed to make upstream migrations to recolonize upstream areas (Cross et al. 1985; Bonner 2000). Thus, impoundments also act as barriers to adult dispersion and preclude source–sink dynamics as well as rescue effects (Winston et al. 1991). Stream fragmentation therefore carries the potential to negatively alter the spatial dynamics of pelagic-spawning cyprinids via interruption of dispersal in space (i.e., in downstream and upstream directions) and time (i.e., during ichthyoplankton and adult life stages; Dudley and Platania 2007; Pompeu et al. in press).

Stream fragmentation might provide a mechanistic pathway useful in predicting population declines among imperiled Great Plains pelagic-spawning cyprinids. Within the Great Plains region of North America, pelagic-spawning cyprinids historically dominated vertebrate assemblages within prairie rivers (Cross and Moss 1987; Gido et al. 2010). Documentation of reproductive strategies and egg types places four broadly distributed imperiled Great Plains cyprinids in this guild: Arkansas River shiner (Moore 1944), peppered chub (Bottrell et al. 1964), plains minnow (*Hybognathus placitus*; Platania and Altenbach 1998), and sturgeon chub (*Macrhybopsis gelida*; Hoagstrom et al. 2006). Similarities in morphology, larval drift catches, and available (although limited) information on reproductive strategy suggest potential for an additional four cyprinids that either broadcast drifting eggs or have an obligatory drifting larval stage: the shoal chub (*Macrhybopsis hyostoma*; Eisenhour 2004), silver chub (*Macrhybopsis storeriana*; Simon 1999), flathead chub (*Platygobio gracilis*; Cross et al. 1985; Durham and Wilde 2008), and prairie chub (*Macrhybopsis australis*; Eisenhour 2004). Numerous proposed drivers exist for the declines of these species, including alterations in streamflow timing and magnitude (Taylor and Miller 1990); poor recruitment associated with reduced streamflows (Wilde and Durham 2008); changes to instream habitat, including substrate compaction and channel homogenization (Cross and Moss 1987); introduction of nonnative taxa; and changes in water quality (Gido et al. 2010). However, reported declines transcend a spatial scale ranging over 20° of latitude and have occurred within 13 regionally distinct North American ecoregions (as defined by Jelks et al. 2008), where all of the above drivers may not be operating. A unifying theme among reported declines is that stream fragmentation is capable of disrupting pelagic-spawning cyprinid life history (as described above) and might represent a primary regulator of species decline. Effects of fragmentation are seemingly not equal among all pelagic-spawning cyprinids, as evidenced by differential levels of extirpation and persistence of guild members within similarly sized fragments (Platania and Altenbach 1998). Consequently, the need exists to identify species-specific threshold levels of fragmentation that might explain declines among numerous fishes across large spatial and temporal scales.

We examined the relationship between stream fragmentation and reported declines among eight species of imperiled Great Plains pelagic-spawning cyprinids. Specifically, we sought to (1) compile literature accounts for the occurrence and status of pelagic-spawning cyprinids within fragmented streams; (2) determine the relationship between population status and stream fragment length; and (3) estimate minimum fragment lengths associated with population persistence. Our test of the extent to which stream fragmentation has imperiled these fishes provides a framework that can be used by managers to select habitats needed to conserve populations of these highly threatened fishes.

Methods

Study Area

The North American Plains comprise a semi-arid region that was historically dominated by grassland, prairie, and steppe biomes that span from Alberta, Canada, to the Rio Grande Basin, Mexico. The plains are bordered to the west by the Rocky Mountains and to the east by the Mississippi River. Consequently, most large-order plains rivers flow west to east within three major basins: the Missouri River, Arkansas River, and Red River basins (Matthews and Zimmerman 1990). These river basins occur in two major plains regions—the Great Plains and Osage Plains (collectively referred to as the Great

Plains hereafter) and span the majority of 10 states: Montana, North Dakota, South Dakota, Wyoming, Nebraska, Colorado, Kansas, Oklahoma, New Mexico, and Texas. Additionally, southern portions of the Great Plains are drained by river basins that empty directly into the Gulf of Mexico, including the Brazos, Colorado, San Antonio Bay, Nueces, and Rio Grande basins. Throughout this region, portions of large prairie rivers characterized by low gradients, sandy bottoms, relatively high turbidity and lying within the coterminous United States were chosen based on inhabitance by pelagic-spawning cyprinids and availability of historical ichthyofauna data.

Evaluating Extent of Stream Fragmentation

Stream fragments were included based on occurrence of instream barriers, historical inhabitance by targeted species, and availability of historical fish assemblage data. Upstream and downstream limits of fragments were defined by one of four instream barriers to fish movement: (1) dams associated with impoundments, hydroelectric energy generation, or water diversions; (2) lentic environments created at upstream extents of reservoirs; (3) stream desiccations occurring as a consequence of anthropogenic water withdrawals; and (4) the upstream natural distribution of targeted species. Distribution of dams was evaluated using the National Inventory of Dams compiled by the United States Army Corp of Engineers and through inspection of aerial photography. Areas of stream desiccation were identified during reviews of literature pertaining to distributions of Great Plains fishes (e.g., Cross et al. 1985; Luttrell et al. 1999), and the period of time for which dewatered streams occurred was quantified using United States Geological Survey (USGS) streamflow data. Streamflow data were downloaded from USGS gauges for the period following most major alterations to flow regime associated with groundwater withdrawals (1969–2009; Milly et al. 2005; Gido et al. 2010), and discharge values (mean annual and monthly median) were quantified and compared to available historical data (pre-1968) using indicators of hydrologic alteration (Richter et al. 1996). Though stream desiccations are likely semipermeable barriers, they were included because of the substantial period of the year in which movement was precluded (Luttrell et al. 1999) and because pelagic-spawning cyprinids typically do not occupy ephemeral streams (Cross et al. 1985). When barriers isolated populations in upstream segments, the extent of target species natural distributions within upstream reaches was based on accounts in Lee et al. (1980) following the methods of Dudley and Platania (2007).

Stream lengths between barriers were quantified in river kilometers (rkm) using the stream layer associated with the National Hydrography Dataset (NHD) from the USGS. Stream lengths were measured along the main channel, excluding oxbows or parallel secondary channels. When data were available, all adjoining main-stem fragments within a basin were targeted. We excluded main-stem sections of the Missouri and Mississippi rivers because of large differences in stream size and relatively sparse historical data. Stream fragment length was then used as a continuous variable to test for species-specific changes in population status and fragment length thresholds in population persistence.

Historical Changes in Fish Assemblages

We reviewed literature accounts regarding the contemporary (1969–2009) and historical (pre-1968) occurrence of eight target species within each fragment. Species were included if found in at least four stream fragments and occurrences were not limited to main-stem Mississippi or Missouri rivers. Confirmed and suspected pelagic-spawning cyprinids targeted throughout the Great Plains were the plains minnow, Arkansas River shiner, sturgeon chub, peppered chub, flathead chub, shoal chub, silver chub, and prairie chub. In general, these species inhabit perennial Great Plains prairie streams where their distributions are limited to main-stem habitats including shallow, braided, and sandy shoals and backwaters where historical (pre-1968) seining data were commonly collected.

Because of differences in sampling methodologies and purposes among published studies, data were used to define four coarse levels of population status: stable, declining, extirpated, and rare. Stable status indicated populations with no reduction in abundance (e.g., density, relative abundance, rank abundance) or distribution (e.g., area inhabited, presence/absence among sampling sites) through time, despite monitoring over a 20-year period. Declining (or depleted) status indicated populations with reductions in either abundance or distribution among sampling periods spread over a period of at least 20 years. Extirpated (or undetectable) status indicated populations not detected within a given fragment in at least 20 years despite continued monitoring. Rare status indicated species that were historically reported within fragments with low frequency or in low abundance; rare occurrences were not included in statistical analyses. Thirty-three published and unpublished accounts were used in describing population statuses of target species. These accounts were partitioned among species-specific descriptions (n = 6; e.g., Luttrell et al. 1999), regional reviews of numerous species-specific accounts (n = 5; e.g., Eisenhour 2004), unpublished assemblage data specific to one or more fragments (n = 4; e.g., G. Wilde, Texas Tech University, unpublished data), and published accounts specific to one or more fragments included in this study (n = 18; e.g., Hoagstrom et al. 2011).

Data Analysis

We used stream fragment length as a continuous independent variable to test the hypothesis that the status of populations occurring within larger fragments is more likely to be stable. A single-factor analysis of variance (ANOVA) was used to test for differences in mean stream lengths for fragments with stable, declining, or extirpated populations of each species. We used a Bonferroni adjustment to control for experiment-wise error associated with conducting ANOVAs for eight species (α = 0.05/8 = 0.006). Post hoc multiple comparisons among the three population types were conducted within species using Fisher's least significant differences (LSD; α= 0.006). Additionally, we tested for differences in population status among grand means of fragment lengths for all species combined (i.e., mean fragment lengths for each population status were combined among species) using an ANOVA and Fisher's LSD.

Initial observations indicated that many species did not persist in shorter fragment lengths, supporting published accounts of pelagic-spawning cyprinid extirpations in shorter fragments of the Rio Grande Basin of New Mexico (Dudley and Platania 2007). Accordingly, we tested for minimum thresholds in fragment length associated with population status of each species using classification tree analysis (CTA; De'ath and Fabricius 2000). We asked whether thresholds existed for species persistence (i.e., extant populations) and local extinction, which might lend insight into the minimum possible fragment length needed to maintain pelagic-spawning cyprinid populations. For extinction threshold analysis, declining and stable populations of species were combined to represent fragments capable of supporting persistence of pelagic-spawning species, although we acknowledge that declining populations may in fact be related to fragment length (Dudley and Platania 2007; this study).

Finally, we used polynomial logistic regression to model fragment length (predictor variable) against extirpations within pelagic-spawning assemblages (i.e., all pelagic-spawning species within a fragment) for each fragment (response variable) to assess the relationship between fragmentation and extirpation at the guild level. The coefficient of determination was calculated using the Nagelkerke R^2 value (Nagelkerke 1991). We then regressed our estimated thresholds in fragment length (predictor variable) against the percentage of extant populations (response variable) for each species to quantify the relationship between fragment thresholds and population persistence.

Results

Within the Great Plains region of North America, 60 stream fragments met the requirements for inclusion in our study (Figure 1). The length of these fragments ranged from 38 to 705 rkm (Table 1). Barriers to fish dispersion included 36 dams associated with water diversions, hydroelectric generation, and reservoir storage; 39 lower bounds defined by impounded water; 21 upper bounds defined by upstream extent of pelagic-spawning cyprinid natural distributions; and 6 localized regions where water withdrawals resulted in reduced discharges and stream desiccation. Streamflows were reduced by 48–83% among fragments associated with stream dewatering, which generally resulted in discharge values of 0 m^3/s throughout pelagic-spawning cyprinid reproductive seasons (May–August) as well as most of the year (up to 310 days; Table 2).

Population status of confirmed or suspected pelagic-spawning cyprinids consisted of 57% extirpated, 21% declining, and 22% stable populations (n = 157 observations among species). Among 90 extirpations, 8 occurred in the northern region of the Great Plains (Montana, North Dakota, South Dakota, Wyoming), 45 in the central region (Nebraska, Colorado, Kansas), and 37 in the southern region (New Mexico, Texas, Oklahoma). Among species, the plains minnow occurred in the greatest number of fragments (n = 48) and the narrowly distributed prairie chub occurred in the fewest (n = 4). Three stream fragments exhibited extensive dewatering and various levels of fragmentation because of temporal variation in stream desiccations between barriers; these included the Arkansas River and upper reaches of the Cimarron River in southwestern Kansas (i.e., fragment ID numbers 33, 40, 41; Cross et al. 1985; Luttrell et al. 1999). We initially retained these fragments in our study because they represented historical occurrences of species, but in each case fragmentation was confounded by loss of a definable fragment length. Among the remaining fragments (n = 57), stream lengths differed according to population status for plains minnow ($F_{2,42}$ = 24.92, P < 0.01, Bonferroni adjusted), Arkansas River shiner ($F_{2,13}$ = 24.97, P < 0.01), sturgeon chub ($F_{2,9}$ = 11.45, P = 0.03), flathead chub ($F_{2,23}$ = 14.40, P < 0.01), shoal chub ($F_{2,13}$ = 15.23, P < 0.01), and silver chub ($F_{2,11}$ = 98.71, P < 0.01). ANOVA could not be conducted for peppered chub or prairie chub because of rare occurrences of persistent populations, but the association between population status and fragment length was consistent with other species (Figure 2). Grand mean river kilometer lengths differed ($F_{2,21}$ = 30.14, P < 0.01) among all species combined and averaged (plus or minus standard deviation) 136 (±21) for extirpated, 226 (±69) for declining, and 458 (±137) for stable populations.

Fragment length thresholds associated with localized extirpations varied by species. Classification tree analysis produced models that significantly differed from random (α = 0.05), successfully classified populations as extant or extirpated (as measured by Cohen's kappa, k), and produced estimated minimum thresholds in fragment length (rkm) associated with population persistence for plains minnow (115 rkm, P < 0.01, k = 0.81), Arkansas River shiner (217 rkm, P = 0.01, k = 0.77), sturgeon chub (297 rkm, P = 0.01, k = 0.79), flathead chub (183 rkm, P < 0.01, k = 0.85), shoal chub (103 rkm, P < 0.01, k = 0.75), and silver chub (203 rkm, P < 0.01, k = 0.8). Model calculation of minimum threshold lengths was not possible for peppered chub or prairie chub because each of these species included only one declining and one stable population. For both species, the median fragment length between declining and extirpated population statuses was used to estimate the minimum threshold necessary for population persistence, resulting in threshold estimates of 205 rkm for peppered chub and 128

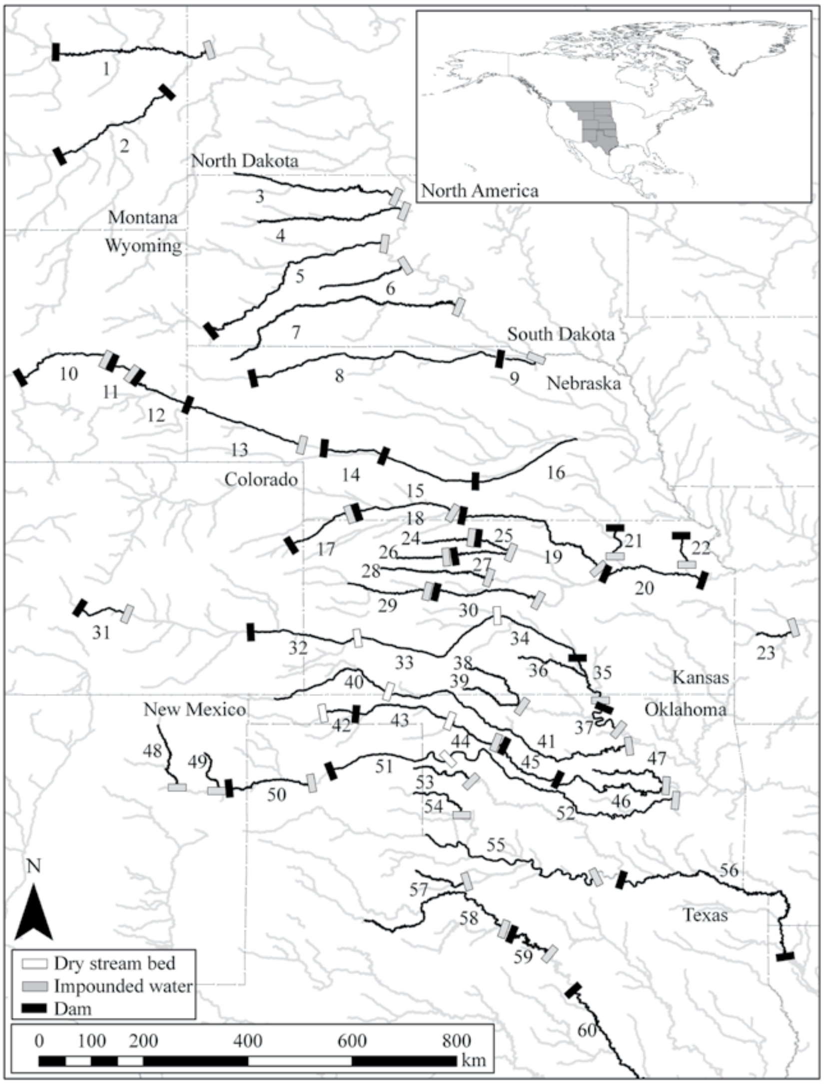


Figure 1. Distribution of North American Great Plains stream fragments included in analyses. Fragment numbers correspond with descriptions in Table 1.

rkm for prairie chub. These estimates combined with CTA results produced minimum length thresholds ranging from 103 to 297 rkm, below which species-specific extirpations occurred.

When pelagic-spawning cyprinid assemblages were considered and the proportion of species extirpated from assemblages regressed against stream fragment length, differential thresholds in persistence contributed to a logistic relationship (Figure 3a). This pattern was characterized by 100% extirpation of pelagic-spawning assemblage members within fragments less than 103 rkm, variable percentages in extirpation among fragments ranging from 103 to 297 rkm, and no reported extirpations among fragments greater than 297 rkm in length. Stream fragmentation explained 71% (Nagelkerke $R^2 = 0.71$, $P < 0.01$) of pelagic-spawning assemblage member extirpations within the 57 stream fragments included in our analysis (excluding fragment ID numbers 33, 40, and 41). Similarly, estimated minimum thresholds in fragment length for the eight species included in our analysis explained 67% ($R^2 = 0.67$, $P < 0.01$) of the variation in the number of extant populations (Figure 3b).

Discussion

Fragmentation Drives Imperilment

Pelagic-spawning cyprinid assemblages inhabiting fragmented streams throughout the Great Plains represent a disappearing guild of fishes, as evidenced by high imperilment rates and conservation listings at state, regional, and national levels (Jelks et al. 2008). Reported reductions in abundance and distribution include extirpation from 45% of its historical range for the sturgeon chub (Rahel and Thel 2004), 55% for shoal chub (Luttrell et al. 1999), 80% for Arkansas River shiner (Wilde 2002), and 90% for peppered chub (Luttrell et al. 1999). Our findings supported extirpation from a majority (i.e., >50%) of fragments included in this study for the flathead chub (61%), silver chub (64%), and sturgeon chub (75%) and values that closely match previously reported extirpations for the Arkansas River shiner (79%) and peppered chub (88%). Similar extirpations have occurred among six species of pelagic-spawning cyprinids in the Rio Grande and Pecos River basins of New Mexico and Texas, where the Rio Grande shiner *Notropis orca* and Rio Grande bluntnose shiner *Notropis simus simus* are now extinct and remaining species are restricted to river fragments more than 100 kilometers in length (Dudley and Platania 2007). Two species of pelagic-spawning cyprinids endemic to the Brazos River of Texas, the sharpnose shiner *Notropis oxyrhynchus* and smalleye shiner *Notropis buccula*, are now restricted to approximately one third of their historical range because of stream fragmentation and associated effects of reservoirs (Durham and Wilde 2009b). These reported patterns of decline are evident across a large spatial extent (i.e., the entire Great Plains), include multiple taxonomic levels (i.e., 4 genera, 16 species, 2 subspecies; Platania and Altenbach 1998; Durham and Wilde 2009b; this study), span 13 North American ecoregions, and collectively include 8% of the imperiled freshwater cyprinids in North America (Jelks et al. 2008). Consequently, pelagic-spawning cyprinids represent a substantial challenge for conservation of biodiversity in North America.

Though previous studies have formulated a number of reasons for observed declines, our synthesis of declines suggests that imperilment of pelagic-spawning cyprinids is a direct con-

TABLE 1. Description, length (rkm), and population status (S, stable; D, declining; E, extirpated; R, rare) of eight Great Plains fishes (1, plains minnow; 2, flathead chub; 3, sturgeon chub; 4, silver chub; 5, shoal chub; 6, peppered chub; 7, Arkansas River shiner; 8, prairie chub) within 60 stream fragments. Full citations for works referenced within the table are available upon request or see Perkin et al. (2010).

	Fragment description	Length	1	2	3	4	5	6	7	8	References
1	Yellowstone River between Fort Peck Dam and upper reaches of Lake Sakakawea	327	S	D	D						18, 19, 33
2	Yellowstone River between Cartersville Dam and Intake Dam	266	S	S	E						18, 19, 33
3	Mainstem Grand River of South Dakota upstream of Lake Oahe	256	S	S	E						29, 30, 33
4	Mainstem Monroe River of South Dakota upstream of Lake Oahe	387	S	S							30, 33
5	Cheyenne River between Angostura Dam and upper reaches of Lake Oahe	395	S	S	S						30, 31, 33
6	Mainstem Bad River of South Dakota upstream of Lake Sharpe	184	S	S							29, 30, 33
7	Mainstem White River of South Dakota upstream of Lake Francis Case	705	S	S	S						30, 33
8	Niobrara River between Box Butte Dam and Spencer Dam	445		S							26, 29
9	Niobrara River between Spencer Dam and upper reaches of Lewis and Clark Lake	65	E	E	E	E					11, 26, 33
10	North Platte River between Alcova Dam and upper reaches of Glendo Reservoir	228	S	D							12, 33
11	North Platte River between Glendo Dam and upper reaches of Guernsey Reservoir	46	E	E	E						11, 26, 33
12	North Platte River between Guernsey Dam to Wyoming/Nebraska diversion dam	96	E	E	E						11, 26, 33
13	North Platte River between Wyoming/Nebraska diversion dam and upper reaches of McConaughy Reservoir	198	S		E						11, 12,33
14	North Platte River between Kingsley Dam and Diversion dam at North Platte, Nebraska	96	E	E							12, 33
15	Platte River North Platte diversion dam to weir dam near Elm Creek, Nebraska	133	D	E	E		D				11, 14, 26, 33
16	Platte River between weir dam near Elm Creek, Nebraska, and Columbus, Nebraska	217	S	D	E	D	D				11, 14, 26, 33
17	Republican River between dam at Bonny, Colorado, and upper reaches of Swanson Reservoir	136		E							4, 26
18	Republican River between Trenton Dam and upper reaches of Harlan County Reservoir	181		E		E	D				4, 11, 33
19	Republican River between Harlan County Dam and upper reaches of Milford Reservoir	332	S	D		D	S				4, 26, 33
20	Kansas River between Milford Dam and Bowersock Dam	177	E	E	E	E	E				4, 6, 11, 33
21	Big Blue River between Marysville Dam and upper reaches of Tuttle Creek Reservoir	66					E				23
22	Delaware River between Mission Lake Dam and upper reaches of Perry Lake	61		E		E	E				4
23	Osage River upstream of upper reaches of Truman Reservoir	85				E	E				16, 20
24	North Fork Solomon River upstream of upper reaches of Kirwin Reservoir	109	E								4, 22, 33
25	North Fork Solomon River between Kirwin Dam and upper reaches of Waconda Reservoir	93	E								4, 22, 33
26	South Fork Solomon River between Hoxie, Kansas, and upper reaches of Webster Reservoir	90	E								4, 22, 33
27	South Fork Solomon River between Webster Dam and upper reaches of Waconda Reservoir	134	E								4, 22, 33
28	Saline River upstream of upper reaches of Wilson Reservoir	189	E			E					4, 15, 33
29	Smokey Hill River between Wallace County, Kansas and upper reaches of Cedar Bluff Reservoir	173	D								15, 33
30	Smokey Hill River between Cedar Bluff Dam and upper reaches of Kanopolis Reservoir	222	D								15, 33
31	Arkansas River between Salida, Colorado, and dam at Florence, Colorado	119		E							26
32	Arkansas River between John Martin Dam and Lakin, Kansas	179		E				E			5, 20, 33
33	Arkansas River between Lakin, Kansas, and Great Bend, Kansas	290	E	E				E	E		5, 20, 27, 28, 33

TABLE 1. (continued)

	Fragment description	Length	1	2	3	4	5	6	7	8	References
34	Arkansas River between Great Bend, Kansas, and weir dam at Wichita, Kansas	178	E	E		E		E	E		5, 20, 27, 28, 33
35	Arkansas River between weir dam at Wichita, Kansas, and upper reaches of Kaw Reservoir	153	D			E	E		E		5, 20, 27, 28, 33
36	Ninnescah/Arkansas rivers between Cairo, Kansas, and upper reaches of Kaw Reservoir	251	D			D		S	D		4, 28, 33
37	Arkansas River between Kaw Dam and upper reaches of Keystone Lake	120	D			E	S	E	E		20, 25, 27, 33
38	Mainstem Medicine Lodge River upstream of upper reaches of Great Salt Plains Lake	165	D					E	E		5, 33
39	Mainstem Salt Fork Arkansas River upstream of upper reaches of Great Salt Plains Lake	163	E					E	E		5, 33
40	Cimarron River between Castaneda, Oklahoma, and just east of Liberal, Kansas	277	E	E				E	E		5, 33
41	Cimarron River between just east of Liberal, Kansas, and Keystone Lake	434	D					E	D		5, 20, 33
42	North Canadian River between Pony Creek confluence and Optima Dam	38	E					E	E		7, 9, 20, 33
43	North Canadian River between Optima Dam and Fort Supply (Wolf Creek Confluence)	191	D					E	E		7, 9, 20, 33
44	North Canadian River between Fort Supply and upper reaches of Canton Lake	139	D					E	E		7, 9, 20, 33
45	North Canadian River between Canton Dam and Overholser Dam, Oklahoma City	161	D					E	E		7, 9, 20, 33
46	North Canadian River between Overholser Dam and upper reaches of Urika Reservoir	339							R		9, 33
47	Deep Fork River upstream of upper reaches of Lake Eufaula	183					E		E		9, 20, 33
48	South Canadian River upstream of upper reaches of Conchas Lake	180	E	E					E		8, 33
49	Ute Creek between Gladstone, New Mexico, to upper reaches of Ute Reservoir	189	D	E				E	E		17, 33
50	South Canadian River between Ute Dam and upper reaches of Lake Meredith	220	D	E				D	D		21. 33
51	South Canadian River between Sanford Dam and Roger Mills County, Oklahoma	214	D	R				E	E		1, 21, 33
52	South Canadian River between Roger Mills County, Oklahoma and Urika Reservoir	462	S				S	R	S		1, 9, 20, 25, 33
53	Washita River upstream of upper reaches of Foss Reservoir	93								E	24, 33
54	North Fork of the Red River upstream of upper reaches of Altus Reservoir	108	E							E	10, 33
55	Upper Red River between Prairie Dog Town Fork and upper reaches of Lake Texoma	455	S							S	13, 33
56	Red River between Denison Dam and Dam at Shreveport, Louisiana	689	S			S	S				25, 33
57	North Fork Wichita River between Truscott, Texas, and upper reaches of Lake Kemp	149	D							D	2, 33
58	Brazos River between McMillan Dam and upper reaches of Possum Kingdom Reservoir	616	S				S				2, 33
59	Brazos River between Morris Sheppard Dam to upper reaches of Lake Waco	171	E				D				3
60	Brazos River downstream of Waco Dam to Gulf of Mexico	645				S	S				32

1: Gene Wilde, Texas Tech University, unpublished data; 2: Fran Gelwick, Texas A&M University, unpublished data; 3: Jack Davis, Brazos River Authority, unpublished data; 4: Keith Gido, Kansas State University, unpublished data; 5: Cross et al. (1985); 6: Cross and Moss (1987); 7: Pigg (1987); 8: Sublette et al. (1990); 9: Pigg (1991); 10: Winston et al. (1991); 11: Hesse et al. (1993); 12: Lynch and Roh (1996); 13: Taylor et al. (1996); 14: Chadwick et al. (1997); 15: Eberle et al. (1997); 16: Pflieger (1997); 17: Pittenger and Schiffmiller (1997); 18: Patton et al. (1998); 19: Helfrich et al. (1999); 20: Luttrell et al. (1999); 21: Bonner and Wilde (2000); 22: Eberle et al. (2002); 23: Gido et al. (2002); 24: Eisenhour (2004); 25: Miller and Robison (2004); 26: Rahel and Thel (2004a); 27: Rahel and Thel (2004b); 28: Haslouer et al. (2005); 29: Hoagstrom et al. (2006); 30: Hoagstrom et al. (2007a); 31: Hoagstrom et al. (2007b); 32: Runyan (2007); 33: Hoagstrom et al. (2010).

TABLE 2. Fragment number, United States Geological Survey (USGS) gauge number, flow period, and historical (pre-1968) and contemporary (1969–2009) values for mean annual flow (MAF; m³/s), median number of zero flow days, and median monthly flow values (m³/s) for cyprinid reproductive seasons (May–August) for stream fragments associated with dewatering and desiccation.

Fragment number	USGS gauge	Flow Period	Historical						Contemporary					
			MAF	Zero days	May	June	July	August	MAF	Zero days	May	June	July	August
33[a]	7139000	1938–2009	5.68	0	0.40	0.76	0.40	0.31	2.97	211	0.00	0.00	0.00	0.00
34[a]	7141220	1999–2009	NA	NA	NA	NA	NA	NA	3.76	119	0.01	0.02	015	0.00
41[a]	7155590	1971–2009	NA	NA	NA	NA	NA	NA	0.23	310	0.00	0.00	0.00	0.00
42[b]	7232500	1932–1993	0.84	2	0.14	0.07	0.09	0.05	0.15	186	0.04	0.00	0.00	0.00
44[b]	7234000	1938–2009	2.79	72	0.86	0.80	0.46	0.03	0.5	60	0.32	0.13	0.00	0.00
52[b]	7228000	1938–2009	11.65	0	0.35	2.34	0.60	0.37	1.94	0	1.46	1.20	0.32	0.27

[a]Desiccations associated with reduced species distributions (Cross et al. 1985).
[b]Desiccations and dewatering associated with reduced species distributions (Pigg 1991).

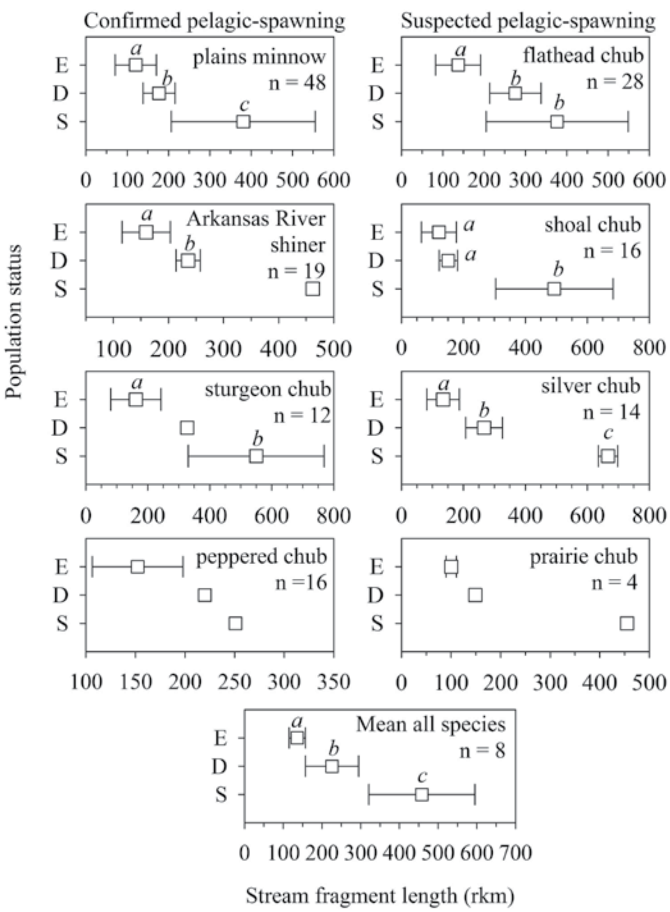


Figure 2. Mean (plus or minus standard deviation) stream fragment lengths (rkm) for confirmed (left column), suspected (right column), and combined (bottom, center) Great Plains pelagic-spawning cyprinid populations according to population status: extirpated (E), declining (D), and stable (S). Lowercase letters represent statistical differences among statuses (see text for statistical procedures).

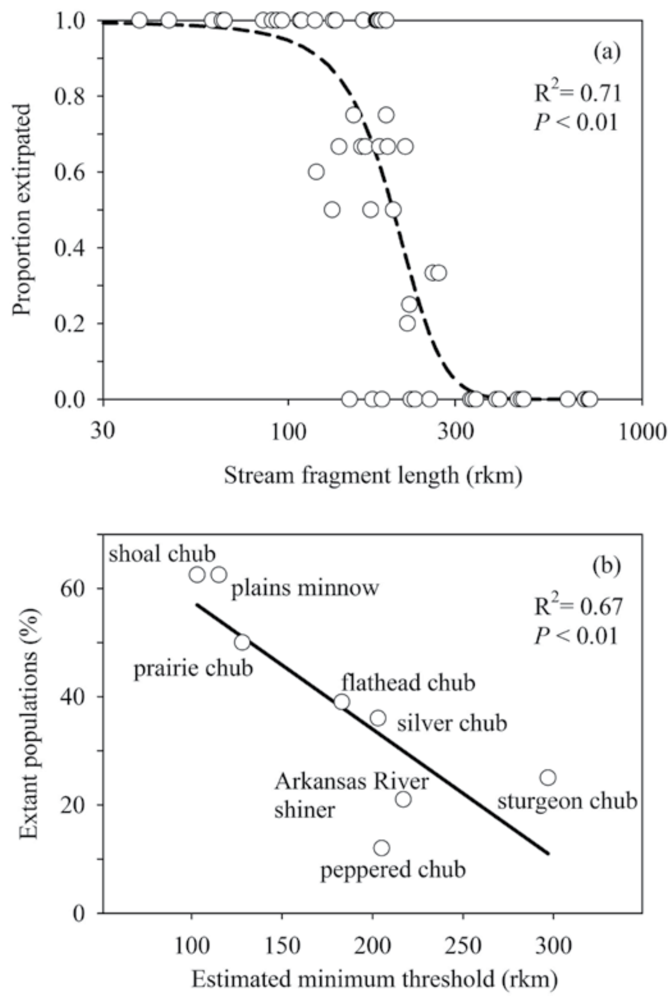


Figure 3. Proportion of species extirpated from Great Plains pelagic-spawning cyprinid assemblages as a function of stream fragment length measured in river kilometers (x-axis log-scaled). (b) Percentage of extant populations for eight Great Plains pelagic-spawning species as a function of the estimated minimum threshold (rkm) necessary for persistence.

sequence of stream fragmentation. This pattern is seemingly driven by instream barriers precluding upstream migration of adults (Luttrell et al. 1999) as well as reduced downstream dispersion and recruitment of drifting ichthyoplankton (Dudley and Platania 2007). Throughout the Great Plains, we found that estimated minimum thresholds in fragment length varied among eight species but were consistently more than 100 rkm in length. Suspected pelagic-spawning shoal chub exhibited the shortest threshold in longitudinal length (103 rkm), which was consistent with Platania and Altenbach's (1998) conclusion that the speckled chub (*Macrhybopsis aestivalis*; once synonymous with shoal chub; Eisenhour 2004) require relatively shorter stream lengths for completion of life history. Our estimated minimum thresholds for Arkansas River shiner and peppered chub (217 and 205 rkm, respectively) were consistent with Bonner and Wilde's (2000) conclusion that the Canadian River between Ute and Meredith reservoirs (220 rkm) represents the near minimum length required for completion of their reproductive cycles. Furthermore, our estimated minimum threshold of 297 rkm for sturgeon chub resembled the apparent minimum stream length necessary for persistence of the closely related sicklefin chub (*Macrhybopsis meeki*; i.e., 301 rkm; Dieterman and Galat 2004).

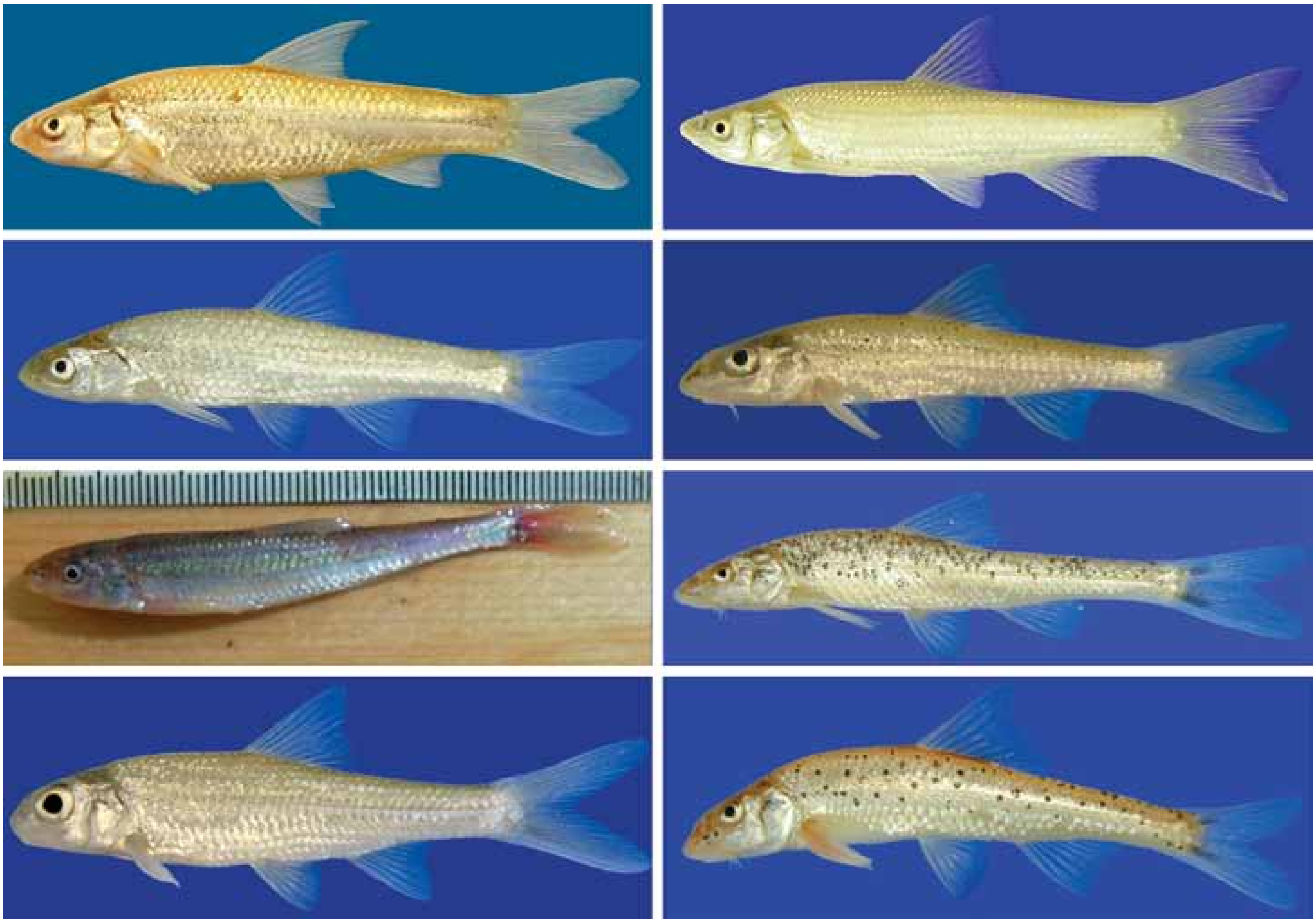
Throughout the Great Plains, we found that extirpation of pelagic-spawning cyprinids occurred to the highest extent in the central and southern Great Plains regions, where notable reductions in discharge have occurred since at least the 1970s

Our results contradict the findings of Medley et al. (2007) and Widmer et al. (2011), who suggested that given the appropriate habitat complexity, reproduction and recruitment of pelagic-spawning fishes is possible in stream fragments less than 100 rkm. However, the above studies were based only on modeling the retention of artificially manufactured eggs and did not consider the many factors that long stream fragments can play in the success of these species (Zymonas and Propst 2009). A notable oversight of these studies is the potential for an obligate drifting larval stage, which might contribute to the need for increased longitudinal distances within fragmented streams given that drifting might not cease at the end of the egg developmental phase. The extent to which larval individuals continue to drift is unknown for many of the species included in this study, but high abundances during drift sampling suggest that drift frequently occurs among larval pelagic-spawning fishes (Simon 1999; Durham and Wilde 2008). The paucity of data related to reproductive mechanisms for suspected pelagic-spawning fishes and for patterns in larval drift among all species in this study suggests that future research into declining Great Plains cyprinids is necessary. However, conservation approaches aimed at mitigating massive declines of poorly studied species necessitate management actions based on the best available biological data (Richter et al. 2003). Imperilment associated with stream fragmentation provides a parsimonious mechanism that links widely dispersed literature accounts of decline among eight highly imperiled Great Plains fishes and likely provides a framework for future investigations related to potential conservation approaches.

The Hierarchal Effects of Fragmentation

Stream fragmentation produces a hierarchy of environmental changes that imperil stream-dwelling fishes through direct and indirect pathways. Notable environmental changes associated with construction of large instream barriers include alteration of downstream flow regimes, water temperatures, and channel morphologies (Poff et al. 1997). Direct consequences of altered flow regimes include removal of high flow pulses that cue synchronization of spawning, increase spawning intensity, and maintain eggs in suspension long enough for hatching (Moore 1944; Bottrell et al. 1964). Reductions in mean annual discharge negatively affect some pelagic-spawning species because recruitment of age-0 individuals is directly dependent upon discharge (Wilde and Durham 2008; Durham and Wilde 2009a). Throughout the Great Plains, we found that extirpation of pelagic-spawning cyprinids occurred to the highest extent in the central and southern Great Plains regions, where notable reductions in discharge have occurred since at least the 1970s (Cross et al. 1985; Gido et al. 2010). In these cases, reductions in discharge likely contributed to declines and extirpations by inducing both fragmentation and negative effects on reproductive success. For example, groundwater withdrawals in western Kansas have contributed to dry streams during 70–99% of pelagic-spawning cyprinid reproductive seasons (May–August), providing limited opportunity for spawning and successful recruitment (Aguilar 2009). Projected changes in climate suggest that this region of the Great Plains will undergo further reductions in stream discharge associated with variation in precipitation and evapotranspiration cycles (Milly et al. 2005). Consequently, the possibility exists for reductions in discharge, related to both anthropogenic withdrawal and climate change, to contribute to an increase in declines and extirpations among Great Plains pelagic-spawning cyprinids in this region (Taylor 2010). This conclusion is consistent with the findings of a recent large-scale literature review that found that alteration to magnitude of discharge was detrimental to many fluvial organisms, notably fishes (Poff and Zimmerman 2010).

Indirect effects of instream barriers such as deep storage reservoirs alter downstream thermal regimes and channel morphologies. Reservoirs that release water from the hypolimnion contribute to cooler tailwater temperatures, and effects extend many kilometers downstream (Edwards 1978). Development rates of drifting eggs and larvae are prolonged during cooler water temperatures, contributing to the need for further downstream transport before free-swimming larval stages are



Great Plains cyprinids suspected or confirmed as members of the pelagic-spawning reproductive guild. Species are (left column, top to bottom) plains minnow (*Hybognathus placitus*), Arkansas River shiner (*Notropis girardi*), sturgeon chub (*Macrhybopsis gelida*), silver chub (*Macrhybopsis storeriana*); (*right column, top to bottom*) flathead chub (*Platygobio gracilis*), shoal chub (*Macrhybopsis hyostoma*), peppered chub (*Macrhybopsis tetranema*), and prairie chub (*Macrhybopsis australis*). Photos courtesy of Chad Thomas (Texas State University; all except sturgeon chub) and Ann Marie Reinhold (Montana State University; sturgeon chub).

reached. Similarly, sustained high flows associated with reservoir releases contribute to increased downstream transport through homogenization of habitat (e.g., deep, incised channels) and increased rate of flow (Dudley and Platania 2007). Our analysis did not include measurements of water temperature or channel morphology, two factors that might be manipulated more easily than removal of large impoundments or diversion dams to facilitate prelarval development within stream fragments (Widmer et al. 2011). However, our findings across a diversity of streams with regional variation in temperature and channel morphology suggest that fragment lengths less than 100 rkm were correlated with extirpation of pelagic-spawning cyprinids in areas upstream of impoundments, where habitat complexity is not altered by reservoir management. This patterned occurred for seven fragments in which 100% of pelagic-spawning cyprinids were extirpated, suggesting that mitigation of extirpation through restoration of habitat complexity should not discount overall fragment length. Additional support for the importance of long river fragments for all eight species included in this study is the occurrence of declining populations within intermediate-length fragments. These declines might be related to time-lag effects associated with reduced reproductive success ultimately arising from changes in flow regime (Perkin and Bonner 2011) or possibly because fragment lengths (i.e., patch sizes) are no longer large enough to support historical population sizes (Aló and Turner 2005).

Mitigation Potential and Broader Implications

Future approaches targeting enhanced conservation of Great Plains pelagic-spawning cyprinids, as well as a diversity of stream-dwelling organisms, will likely require restoration or preservation of connectivity within stream systems. In particular, the use of fishways that allow passage in an upstream direction for a wide range of fishes (Prchalová et al. 2006) are likely of great conservation value. However, a paucity of empirical data exists pertaining to the passage of small-bodied cyprinids through fishways, though existing evidence suggests that passage is possible (Prchalová et al. 2006; Bestgen et al. 2010).

The greater challenge will ultimately involve the downstream passage of drifting ichthyoplankton, especially through large reservoirs (Agostinho et al. 2007; Pompeu et al. in press). We are unaware of initiatives aimed specifically at allowing the downstream transport of ichthyoplankton through reservoirs in fragmented river systems, which is perhaps the greatest challenge associated with conservation of pelagic-spawning cyprinids. Additional conservation options for mitigating the effects of fragmentation include management of flow regimes that target recruitment of native fishes (Propst and Gido 2004), release of epilimnetic water to minimize thermal alterations (Dudley and Platania 2007), and management of instream habitat complexity to facilitate increased heterogeneity (Widmer et al. 2011). Ecological benefits of these mitigation approaches hold potential for improving the conservation status of many diadromous and freshwater fishes not included in this study (Jelks et al. 2008) as well as riparian vegetation forms, unionid mussels, and aquatic invertebrates (Lytle and Poff 2004). Unregulated, interconnected river systems have driven the adaptation and evolution of fluvial organisms, and preservation of stream communities will ultimately require trade-offs between ecological needs of streams and human needs associated with freshwater resources (Richter et al. 2003; Lytle and Poff 2004; Limburg et al. 2011). Restoration approaches targeting improvement at riverscapes scales hold potential for successful species and ecosystem preservation; however, such approaches are limited by the ability to identify appropriate spatial scales at which to implement management actions (Fausch et al. 2002). Our findings suggest that providing connectivity at spatial scales on the order of hundreds of river kilometers is likely necessary for the preservation of at least one diverse functional group of stream-dwelling organisms in the Great Plains, which is consistent with recent calls for improving or maintaining connectivity within steams across the globe (e.g., Nilsson et al. 2005; Agostinho et al. 2007; Dudley and Platania 2007).

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Contrasting Global Game Fish and Non-Game Fish Species

Michael R. Donaldson

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, 1125 Colonel By Drive, Ottawa, ON, Canada, K1S 5B6; and Centre for Applied Conservation Research, Department of Forest Sciences, University of British Columbia, 2424 Main Mall, Vancouver, BC, Canada, V6T 1Z4. E-mail: mdonald@interchange.ubc.ca

Connie M. O'Connor

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, 1125 Colonel By Drive, Ottawa, ON, Canada, K1S 5B6

Lisa A. Thompson

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, 1125 Colonel By Drive, Ottawa, ON, Canada, K1S 5B6

Andrew J. Gingerich

Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana–Champaign, IL, USA, 61820

Sascha E. Danylchuk

Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana–Champaign, IL, USA, 61820

René R. Duplain

Department of Biology, University of Ottawa, Ottawa, ON, Canada, K1N 6N5

Steven J. Cooke

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, 1125 Colonel By Drive, Ottawa, ON, Canada, K1S 5B6

ABSTRACT: *We compared biological and ecological traits between global game fish and non-game fish species using an analysis with randomly chosen fish species from each group and an analysis where species were matched by body length. We used data from the International Game Fish Association (IGFA), FishBase, and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Game fish species were defined as being present in the IGFA world record list. The random comparison revealed that on average game fish were significantly larger (155.0 ± 121.5 versus 34.1± 59.5 cm), occupied shallower minimum depths (19.4 ± 58.8 versus 130.0± 359.0 m), had a broader latitudinal range (51°.2 ± 29.4°versus 31.1°± 25.9°), and significantly higher trophic levels (4.1 ± 0.1 versus 3.4± 0.1 trophic units) than non-game fish species. The length-matched analysis similarly identified that game fish species occupied higher trophic levels than non-game fish(3.9 ± 0.4 versus 3.6± 0.6 trophic units), but latitudinal range and depth associations did not differ between groups. Both the random and length-matched analyses revealed that game fish were more commonly found in freshwater than non-game fish. Both*

Comparación global entre especies reservadas y no reservadas a la pesca recreativa

RESUMEN: Se realizó una comparación global de los atributos biológicos y ecológicos entre especies de peces reservadas a la pesca recreativa y aquellas que no lo están, mediante una selección al azar de especies de cada grupo y mediante un análisis en el que las especies se sorteaban de acuerdo a su talla. Se utilizaron datos provenientes de la Asociación Internacional de Pesca Deportiva (AIPD), FishBase y de la Lista Roja de la Unión Internacional para la Conservación de la Naturaleza (UICN). El selección de especies reservadas y no reservadas a la pesca recreativa se realizó considerando aquellas que estaban presentes en el registro mundial de la AIPD y aquellas que no se encontraron bajo el nombre de "pesca recreativa" en FishBase. La comparación al azar entre los dos grupos mostró que, en promedio, las especies de pesca recreativa fueron significativamente más grandes (155.0 ± 121.5 versus 34.1 ± 59.5 cm), ocuparon profundidades mínimas más someras (19.4 ± 58.8 versus 130.0 ± 359.0 m), presentaron una distribución latitudinal más amplia (51.2 ± 29.4 versus 31.1 ± 25.9) y pertenecieron a niveles tróficos significativamente más altos (4.1 ± 0.1 versus 3.4 ± 0.1 unidades) que aquellas especies no reservadas a la pesca recreativa. En el sorteo por similitud de tallas se evidenció algo parecido, siendo las especies de pesca recreativa las que ocuparon niveles tróficos mayores (3.9 ± 0.4 versus 3.6 ± 0.6 unidades), pero los rangos latitudinales y de profundidad no difirieron entre los grupos. Tanto el sorteo al azar como el de similitud de tallas mostraron que los peces dulceacuícolas eran las especies más comúnmente encontradas en la pesca recreativa en comparación que las del otro grupo. Los análisis, así mismo, indicaron que las especies de la pesca recreativa eran especies más migratorias y que ambos grupos diferían en cuanto a distribución geográfica. El sorteo al azar mostró que las especies de la pesca recreativa eran, con mucha mayor frecuencia, también objeto de la pesca comercial, menos resilientes y más amenazadas que las que no son de pesca recreativa. Si bien se debe tener cuidado al sintetizar información proveniente de bases globales de datos, en el presente estudio se identifican diferencias importantes entre especies reservadas y no reservadas a la pesca recreativa, lo cual es relevante para las iniciativas de conservación y manejo.

analyses found that game fish species were more migratory and that both groups differed in their geographical distributions. The random comparison revealed that game fish were significantly more targeted by commercial fisheries, less resilient, and more threatened relative to non-game fish. Caution must be exercised when synthesizing data from broad data sources, yet this study identifies important differences between game fish and non-game fish species, which are relevant to management and conservation initiatives.

Introduction

Worldwide, recreational and game fisheries have become popular and economically important industries. Recreational fishing participation rates vary widely among countries but are estimated to be about 10.6% worldwide (Arlinghaus and Cooke 2008), generating billions of dollars of direct and indirect revenue (Cowx 2002). In the United States alone, recreational fishing generated over $35 billion in gross revenues in 2001 (U.S. Fish and Wildlife Service 2001). In terms of biomass, game fish have been estimated to represent up to 12% of the global fish catch (Cooke and Cowx 2004) and in some fisheries can represent up to 90% of the annual harvest (National Research Council 2006). Despite the economic importance and scope of this industry, only recently have researchers and managers begun to assess the scale and consequences of the recreational fisheries sector and are now recognizing the importance of incorporating this information into assessments of the conservation status of fish populations (Post et al. 2002; Coleman et al. 2004; Arlinghaus and Cooke 2005; Lewin et al. 2006).

Little is known about the biological traits that differentiate game fish from non-game fish species, particularly at a global scale.

Fisheries management and conservation efforts require a basic understanding of the general biology, population dynamics, and harvesting regimes of vulnerable species. At a global scale, many fisheries are data limited (Vasconcellos and Cochrane 2005;Mora et al. 2009), and the global recreational fisheries sector has been hampered by poor data collection on participation and harvest rates (Cooke and Cowx 2004, 2006), posing challenges for fisheries management and conservation. As a consequence, little is known about the biological traits that differentiate game fish from non-game fish species, particularly at a global scale. We used the best available data from three publicly available databases to test the hypothesis that game fish species have unique biological features that distinguish them from non-game fish at a broad, global scale. We conducted two sets of comparisons that contrast a suite of biological and ecological traits between game fish and non-game fish species. We also discuss the limitations of the datasets and approach used here, recognizing that at present they represent the best available data to conduct such analyses.

Materials and Methods

Random and Length-Matched Analyses

We contrasted several characteristics of game fish and non-game fish species using three publicly available databases: the International Game Fish Association (IGFA) World Record List (IGFA2006b), FishBase (Froese and Pauly 2008), and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2008). The IGFA World Record List was used to assemble an initial list of species that were known to be targeted at a global scale (see Appendix). The game fish species included here are not meant to be an all-inclusive list of all possible game fish species but instead represent species that are commonly targeted for world record catches worldwide. FishBase was used to randomly select non-game fish species for comparisons, which were selected for inclusion based on a randomly generated number system. The random selection process involved generating a list of all species in FishBase and importing this list into a spreadsheet program. Each entry was assigned to a randomly generated number. The list was randomized and the top-ordered non-game species were selected to compare to the species identified on the IGFA list. For inclusion, non-game fish were required to contain data in at least 75% of the categories being examined to facilitate statistical comparisons between game fish and non-game fish. Though this resulted in our comparison not being truly random, it was necessary to ensure that non-game fish species included sufficient data to be used for statistical comparisons. This method also ensured that non-game fish were not artificially biased toward data-deficient species. Species were considered non-game fish as long as they were not included on the IGFA list and not listed as “game fish” in FishBase.

The random comparison derived from data from FishBase revealed that, on average, game fish were significantly larger than non-game fish species. Body length may differentially affect a number of the traits examined in this study, so to avoid missing key comparisons that may either be driven or masked by body length, we present both the random analysis and the length-matched comparison. The length-matched comparison was conducted by first randomly selecting game fish species from FishBase (using the methods described above for the random comparison) and then sorting fish by recorded total length and populating a list of game fish and non-game fish that did not differ statistically in size (determined by t-test). This procedure resulted in a database of equal numbers of game fish and non-game fish species that did not differ in body length. In the length-matched comparison, only fish species for which reliable total length data (i.e., cited from a peer-reviewed source) were included, resulting in a smaller subset of species (i.e., smaller sample size) used in the length-matched comparison relative to those in the random comparison. In total, there were

328 species from the IGFA listed as game fish in our random analysis and 225 game fish species from the IGFA list for the length-matched analysis. In each analysis, an equal number of randomly selected non-game fish species was included for comparisons with game fish species. Maximum length represents the maximum published total length data that were available for a species in FishBase. For approximately 20 species, total lengths were not available, so standard lengths or fork lengths were used to approximate total lengths.

International Game Fish Association World Record List

The IGFA World Record List is a database that maintains records for global marine and freshwater fish species (the regulations for these different classifications are described in detail in IGFA 2006a, 2006b).The IGFA states that species captured by rod, reel, line, and hook are eligible to be added to the list, provided that the capture meets IGFA regulations. The IGFA stipulates that fish must be captured by the laws and regulations that govern a particular species in a particular region, must be regularly recreationally angled with a rod and reel in the general area of capture, and cannot be captured in hatchery or sanctuary waters. In this article, we define a game fish as a species that fits the criteria to be eligible for inclusion on the IGFA World Record List. New records for species of conservation concern are not added to the IGFA World Record List, but standing records for species of conservation concern remain on the list (Jason Schratwieser, personal communication). Although headquartered in the United States, IGFA membership is open to persons of all nationalities. Nonetheless, it is possible that the species in the IGFA list tend to be focused in developed nations (particularly North America) or destination fisheries in developing countries (e.g., bonefish [*Albula* spp., Albulidae] in the Seychelle Islands). The IGFA lists fish by species; however, some entries are grouped by family or genus due to identification problems with morphologically similar congeners that are difficult to identify. For this study, we expanded these groups to the species level (i.e., we examined each applicable species within the genus and included species-specific data from FishBase for each) to obtain species-specific data from FishBase, rather than generalizing to the genera level: dorado (*Salminus* spp., Characidae), snakehead (*Channa* spp., Channidae), sorubim (*Pseudoplatystoma* spp., Pimelodidae), bonefish, Pacific bonito (*Sarda* spp., Scombridae), ladyfish (*Elops* spp., Elopidae), hammerhead shark (*Sphyrna* spp., Sphyrnidae), mako shark (*Isurus* spp., Lamnidae), thresher shark (*Alopias* spp.,Alopiidae), snook (*Centropomus* spp., Centropomidae), sturgeon (Acipenseridae family), and ground shark (Carcharinidae family).To ensure that non-game fish species were not erroneously included in analyses, we excluded species that had overlapping genera with the aforementioned expanded families.

FishBase

FishBase is a comprehensive database that contains data on approximately 31,800 global fish species. For species in each analysis, we used FishBase to assemble the database of biological, ecological, and life history characteristics. Data obtained from FishBase included the following continuous variables: maximum length, trophic level, latitude range, maximum water depth (i.e., the deepest water depth that has been recorded for each species), and minimum water depth (i.e., the shallowest water depth that has been recorded for each species). Data obtained from FishBase included the following categorical variables: general habitat (freshwater, marine), habitat (demersal, reef-associated, benthopelagic, pelagic, bathypelagic, bathydemersal), migratory status (nonmigratory, migratory; i.e., amphidromous, oceanodromous, anadromous, catadromous, potamodromous), climate (tropical, subtropical, temperate, boreal, polar, deepwater), hemisphere, level of commercial fishing (no commercial fishery/of no interest or grouped together as subsistence, minor, commercial, highly commercial), and resilience (minimum population doubling time; high [<15 months], medium [1.4–4.4 years], low [4.5–14 years], very low [>14 years]). Trophic-level data were obtained as a calculated value from FishBase where both diet composition and food item trophic levels are taken into account. The trophic levels of a given group of fish (individuals, population, species) is estimated as trophic level = 1 + mean trophic level of the food items, where the mean is weighted by the contribution of the different food items (Froese and Pauly 2008).

International Union for Conservation of Nature Red List

The IUCN Red List of Threatened Species across the globe is a database of global species of conservation concern across the globe. Species that had been assessed by IUCN were categorized conservatively as either not threatened (i.e., IUCN categories for data deficient, least concern, and near threatened) or threatened (i.e., IUCN categories for vulnerable, endangered, and critically endangered).

Statistical Analyses

Normality was assessed visually using a normal quantile plot. Heteroscedasticity was assessed using Levene's test. Pearson's chi-square tests for independence were used to determine whether there were statistically significant differences between game fish and non-game fish species for each of the categorical variables (e.g., to test whether game fish species are more likely to occur in marine or freshwater habitat).Welch's analyses of variance were used to assess differences between game fish and non-game fish species for each of the continuous variables. A nonparametric approach was necessary because transformations failed to solve violations of the assumption of normality. A Bonferroni correction was performed at the 0.05 significance level to account for multiple comparisons based on the 13 statistical tests performed in each of the random and length-matched comparisons (Zar 1996) and resulted in a corrected significance level of a = 0.004. Unless noted otherwise, all reported values are means plus or minus one standard deviation (SD). For both length-matched and random comparisons, statistical analyses were conducted using JMP 7.0 (SAS Institute Inc., Cary, North Carolina).

Results

The random comparison revealed that relative to non-game fish, game fish species were significantly larger, occupied shallower minimum depths, had a broader latitudinal range, and occupied significantly higher trophic levels (Figure 1). The length-matched analysis similarly identified that game fish species occupied higher mean trophic levels than non-game fish, but latitudinal range and depth associations did not differ between groups (Table 1).

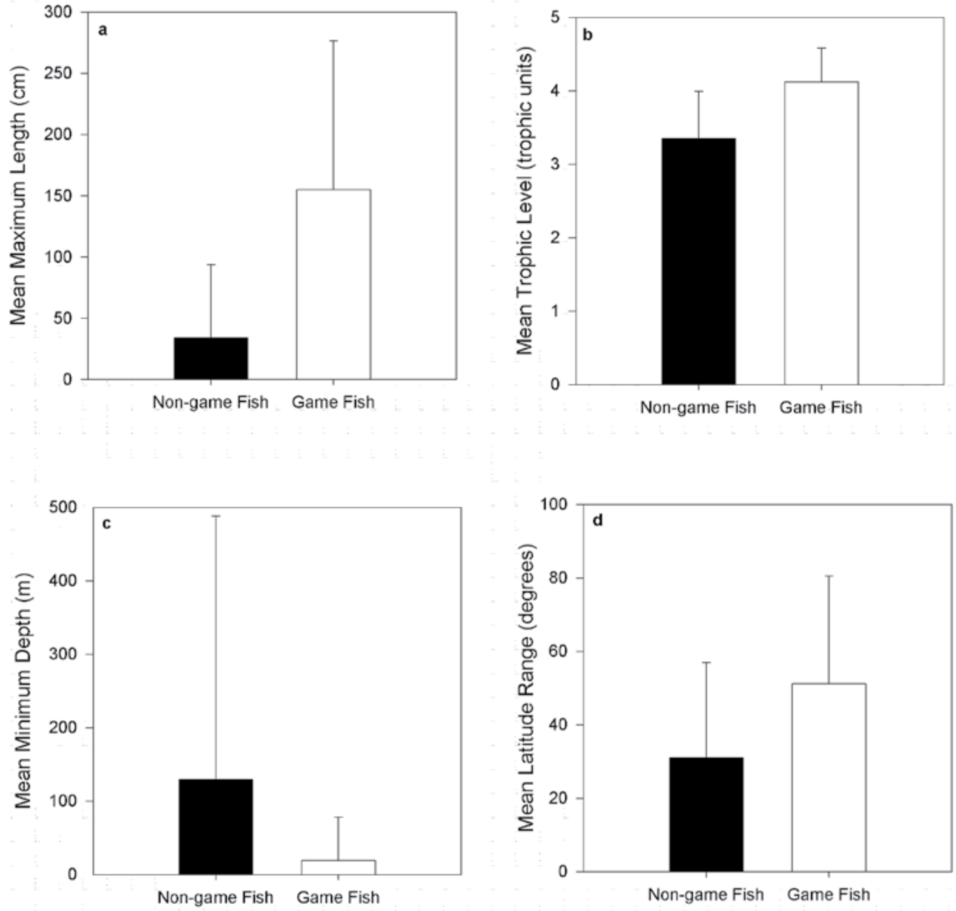

Figure 1. Results of the random comparison that contrasts the continuous variables that characterize game fishand non-game fish species:(a) maximum length, (b) trophic level, (c) minimum depth, and (d) latitude range.Table 1 shows statistical results.

Game fish species associated more often with freshwater habitats (39.9% for the random comparison and 51.7% for the length-matched comparison) than non-game fish species (19.7% for the random comparison and 19.9% for the length-matched comparison; Table 2, Figures 2a and 3a). In both analyses, game fish and non-game fish tended to differ in their habitat associations (Table 2). Demersal habitat associations were most common for both non-game fish and game fish species in each analysis. Game fish were more frequently associated with benthopelagic and pelagic habitats relative to non-game fish, but non-game fish were unique to both bathydemersal and bathypelagic habitats (Figures 2b and 3b). In both analyses, climate association varied significantly between groups (Table 2). Game fish were most commonly associated with tropical, subtropical, and temperate regions. Non-game fish were found primarily in tropical regions, as well as in deepwater, subtropical, temperate, and boreal/polar regions (Figures 2c and 3c). In the random analysis, game fish had larger latitudinal ranges than non-game fish (Table 1), but this was not apparent in the length-matched analysis (Table 1). In both analyses, relative to non-game fish, game fish species were more likely to be migratory (Table 2, Figures 2d and 3d). Game fish occurred primarily in the northern hemisphere (39.9% in the random comparison and 52.3% in the length-matched comparison) or both hemispheres (56.6% in the random comparison and 44.6% in the length-matched comparison), whereas non-game fish were distributed between both hemispheres (43.5% in the random comparison and 61.6% in the length-matched comparison; Table 2, Figures 2f and 3e).

The random comparison revealed that game fish (92.1%) are significantly more targeted by commercial fisheries than non-game fish (50.9%) and are less resilient (61.1%) compared to non-game fish (15.1%; Table 2, Figure 2e). However, in our length-matched analysis we did not find significant differences between groups for commercial fishing pressure or resilience (Table 2). The random analysis revealed that game fishare more threatened than non-game fish based on the 2008 IUCN Red List, whereas the length-matched analysis did not reveal significant differences between groups. In the random analysis, 11.9% of non-game fish species and 24.4% of game fish species were evaluated by IUCN compared to 18.2% of non-game fish species and 19.1% of game fish species in the length-matched analysis (Table 3). IUCN 2008 Red List status (i.e., species categorized as vulnerable, endangered, or critically endangered)

TABLE 1. Comparison of characteristics between game fish and non-game fish for continuous variables.

Characteristic	Group	Random comparison						Length-matched comparison					
		n	Mean	SD	*F*	*df*	*P*	*n*	Mean	SD	*F*	*df*	*P*
Maximum body length (cm)	Game fish	313	155.0	121.5	636.5	1	<0.001	225	108.3	77.3	2.1	1	0.051
	Non-game fish							225	93.4	90.2			
Minimum depth (m)	Game fish	116	19.4	58.8	14.3	1	<0.001	135	26.1	70.2	5.9	1	0.015
	Non-game fish	178	130.0	359.0				180	83.1	264.9			
Maximum depth (m)	Game Fish	116	287.9	788.8	1.2	1	0.3000	132	245.7	894.9	4.9	1	0.027
	Non-game fish	178	438.9	721.2				179	448.0	707.7			
Latitudinal range (°)	Game fish	265	51.2	29.4	68.0	1	<0.001	185	40.7	24.8	0.6	1	0.454
	Non-game fish	206	31.1	25.9				172	42.7	26.5			
Trophic level (trophic units)	Game fish	184	4.1	0.1	61.8	1	<0.001	189	3.9	0.4	39.4	1	<0.001
	Non-game fish	49	3.4	0.1				177	3.6	0.6			

TABLE 2. Comparison of characteristics between game fish and non-game fish for categorical variables.

Characteristic	Group	Random comparison				Length-matched comparison			
		n	$\chi 2$	*df*	*P*	*n*	$\chi 2$	*df*	*P*
General habitat	Game fish	328	31.7	1	<0.001	225	43.2	1	<0.001
	Non-game fish	328				225			
Habitat	Game fish	322	149.8	5	<0.001	225	62.3	5	<0.001
	Non-game fish	328				225			
Climate	Game Fish	319	133.4	4	<0.001	223	44.5	4	<0.001
	Non-game fish	326				225			
Hemisphere	Game fish	265	54.3	2	<0.001	185	44.1	2	<0.001
	Non-game fish	210				189			
Migratory status	Game fish	165	91.9	5	<0.001	108	87.1	5	<0.001
	Non-game fish	79				146			
Resilience	Game fish	309	141.0	3	<0.001	215	0.3	3	0.963
	Non-game fish	303				215			
Commercial fisheries	Game fish	290	141.0	1	<0.001	208	0.1	1	0.888
	Non-game fish	208				200			
IUCN threatened status	Game fish	328	10.89	1	<0.001	225	1.7	1	0.193
	Non-game fish	328				225			

differed significantly between groups in the random comparison (8.2% of game fish, 3.4% of non-game fish) but did not differ significantly in the length-matched comparison (8.4% of game fish, 5.3% of non-game fish; Table 2). To put these values into context, of the approximately 31,800 total species described in FishBase, 3,481 (~11.0%) fish species have been evaluated by IUCN and 1,275 (~4.0%) species are listed as threatened on the IUCN Red List 2008.

Discussion

Many of the traits that were significantly different between game fish and non-game fish were consistent with differences in geographic associations, including general habitat (i.e., marine versus freshwater), aquatic habitat (e.g., demersal, pelagic), climate, and hemisphere. Game fish are less common in bathypelagic or bathydemersal regions. In the marine environment, these results may reflect the limitations of fishing gear

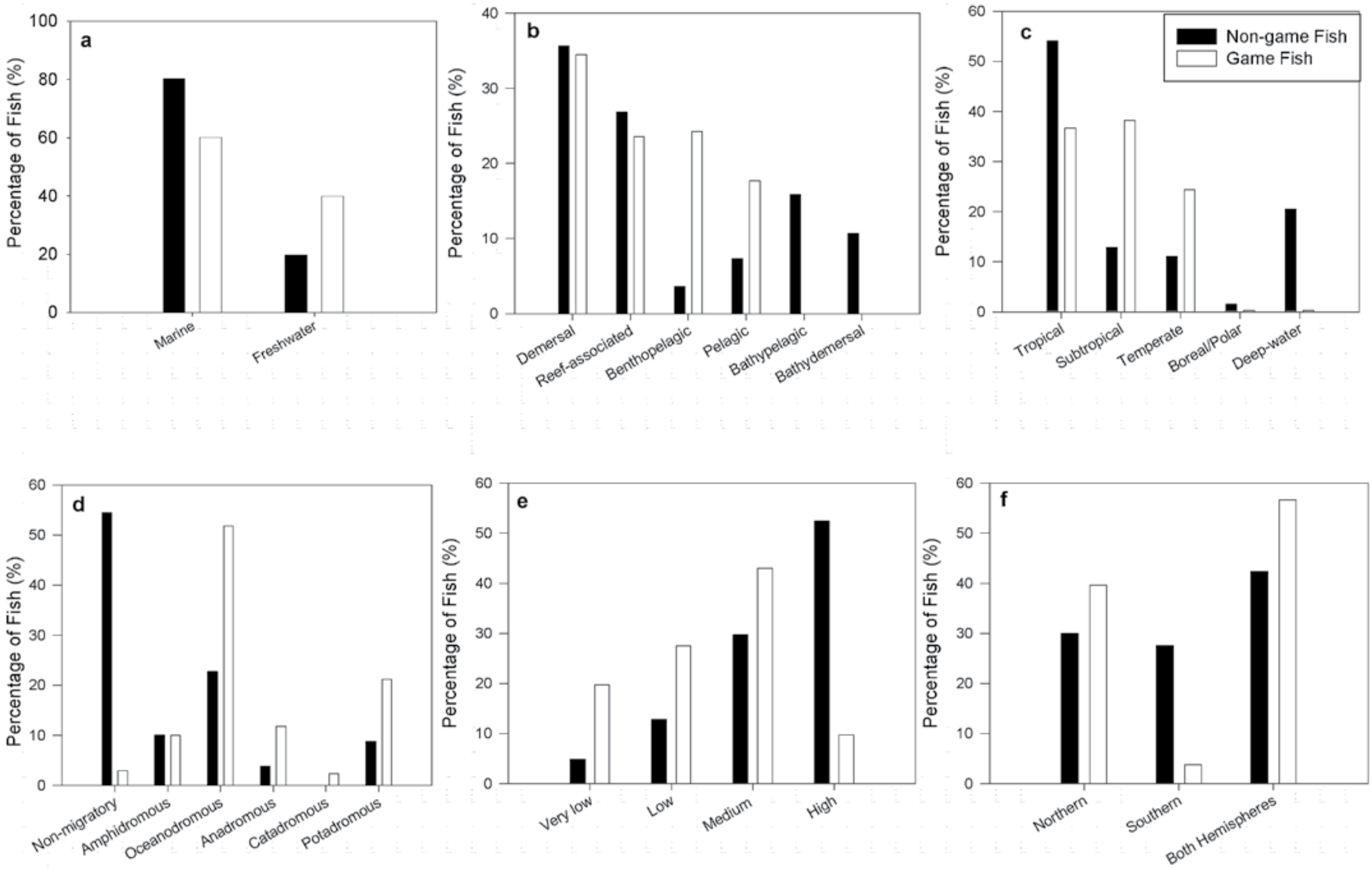

Figure 2. Results of the random comparison that contrasts the categorical variables that characterizegame fishand non-game fish species:(a) general habitat, (b) habitat, (c) climate, (d) migratory status, (e) resilience, and (f) hemisphere.Table 2 shows statistical results.

to exploit deeper water and open seas. Recreational fisheries tend to target areas that are accessible by standard recreational fishing gear, including near shore, shallow regions, estuaries, reefs, mangroves, and embayments in marine habitats (Coleman et al. 2004; Cooke and Cowx 2004) and most freshwater habitats (Arlinghaus et al. 2002; Arlinghaus and Cooke 2005). Game fish that occupy marine pelagic and benthopelagic habitats are frequently targeted only when they are in aggregations due to behavioral (e.g., migratory) or habitat-mediated means (Coleman et al. 2004). In contrast, bathydemersal and bathypelagic species tend to occupy deep regions (i.e., greater than 1km deep) and thus may avoid fishing pressure. However, the development of new deepwater recreational fishing technology (Roberts 2002) suggests that fish at depths may become increasingly targeted and has already been identified as a major conservation concern for marine commercially targeted fish stocks (Morato et al. 2006).

The differences between game fish and non-game fish in terms of climate, as well as latitude range in the random comparison, may reflect human population distribution (e.g., anglers tend to fish close to home; Post et al. 2002).This finding could be related to the fact that the majority of data for recreational fisheries participation are from developed countries in North America and Europe,and there is unequal reporting on participation from other countries (Arlinghaus et al. 2002; Cooke and Cowx 2006). Unfortunately, there are few data on recreational fishing participation rates or harvest in developing countries because the distinction between recreational and subsistence fishing is often not possible (Aas 2002), landings are often unmonitored and unreported, and there is a lack of wealth and funding (European Inland Fisheries Advisory Commission 2008). However, the extent of recreational fishing in developing countries may be relatively large, due to high human population and subsequent fishing pressure (Allan et al. 2005). If latitude range is taken as a measure of general tolerance, then larger ranges should make these species more tolerant to changing environmental conditions (Malakoff 1997), and it has been hypothesized that this would make species less susceptible to imperilment from fishing pressure (Froese and Torres 1999).However, field studies and models of the relationship between latitude range and vulnerability have found limited evidence that this occurs in marine systems (Dulvy and Reynolds 2002).The latitude ranges measured here may be influenced by migratory status. For example, of the 50 game fish with the largest latitude ranges, 37 are considered “highly migratory species” by Annex I of the 1982 Law of the Sea Convention (United Nations 1982). The larger latitudinal ranges

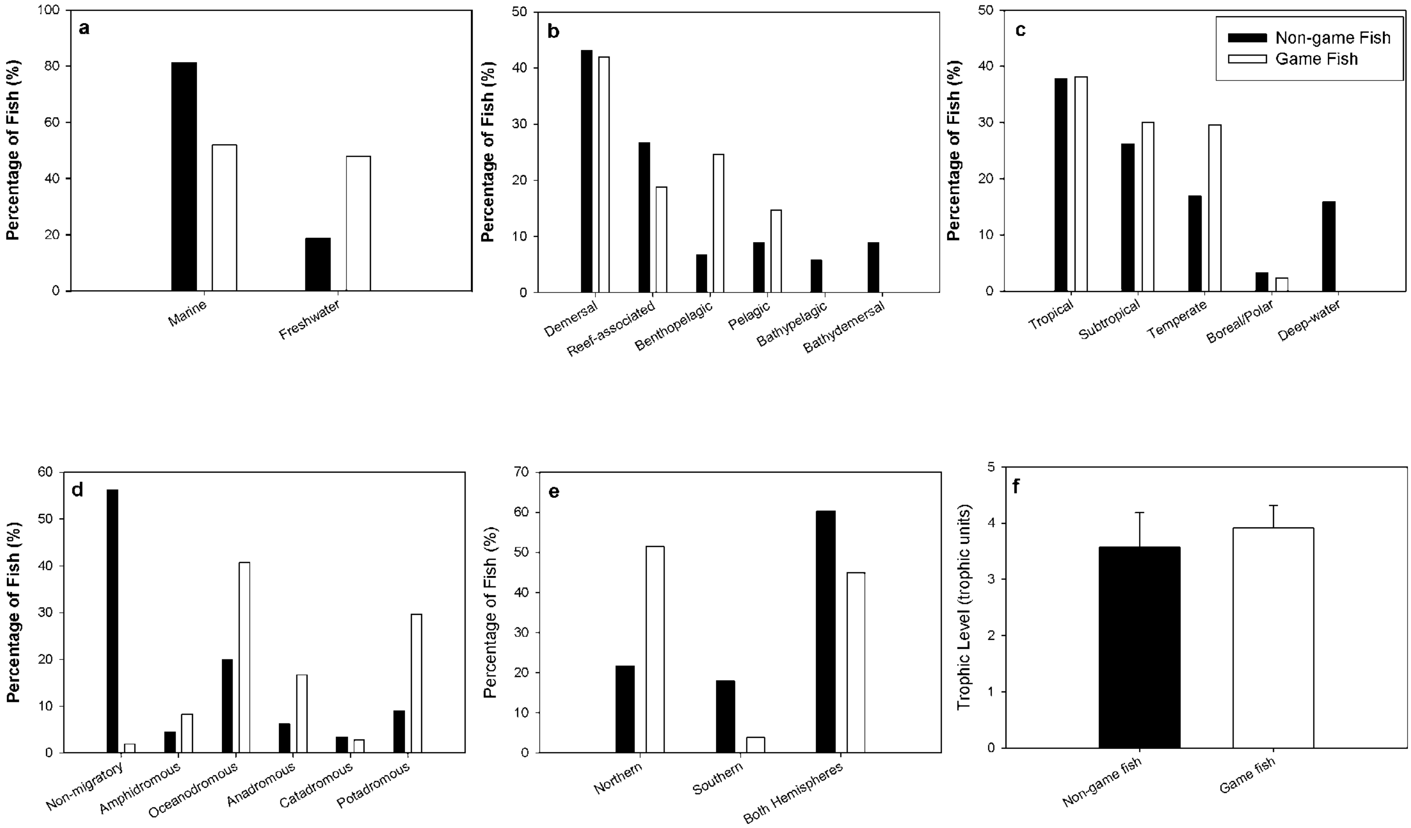

Figure 3. Results of the length-matched comparison that contrasts the characteristics of game fish and non-game fish species:(a) general habitat, (b) habitat, (c) climate, (d) migratory status, and (e) hemisphere.Tables 1 and 2 show statistical results.

TABLE 3. A summary of the number of game fish and non-game fish species that have been evaluated under the IUCN Red List 2008.Categories include data deficient (DD), least concern (LC), low risk/near threatened (LRNT), near threatened (NT), vulnerable (VU), endangered (EN), and critically endangered (CR).Percentages reflect the number of species in a particular IUCN category in relation to the total number of species examined in each analysis (n = 328 in random comparison, n = 225 in length-matched comparison).

IUCN Category	Random comparison		Length-matched comparison	
	Non-game fish *n* (% of overall)	Game fish *n* (% of overall)	Non-game fish *n* (% of overall)	Game fish *n* (% of overall)
DD	8 (2.4)	10 (3.1)	7 (3.1)	7 (3.1)
LC	14 (4.3)	20 (6.1)	12 (5.3)	15 (6.7)
LRNT	4 (1.2)	7 (2.1)	2 (0.8)	7 (3.1)
NT	2 (0.6)	16 (4.8)	1 (0.4)	2 (0.8)
VU	6 (1.8)	17 (5.2)	5 (2.2)	7 (3.1)
EN	4 (1.2)	4 (1.2)	9 (4.0)	3 (1.3)
CR	1 (0.3)	6 (1.8)	5 (2.2)	2 (0.8)
Total	39 (11.9)	80 (24.4)	41 (18.2)	43 (19.1)

of the game fish examined in this study are also linked to the introductions of popular game fish species outside of their endemic range (Cambray 2003). Of the 50 game fish species with the largest latitude ranges, 9 species have ranges that can be attributed to distribution rather than migrations. Of these, several species (e.g., rainbow trout [*Oncorhynchus mykiss*, Salmonidae], brown trout [*Salmo trutta*], brook trout [*Salvelinus fontinalis*, Salmonidae], lake trout [*Salvelinus namaycush*, Salmonidae]) are widely introduced game fish species, and rainbow trout is globally considered one of the most highly invasive species (Invasive Species Specialist Group 2004).

Though migration has often been linked to conservation concerns by both environmental factors and fisheries pressure (Jonsson et al. 1999; McDowall 1999), the link between migration status and recreational fishing has rarely been considered. We found that game fish were more likely to be migratory than non-game fish. Fish migrations tend to be cyclical and predictable in both timing and location and, accordingly, migratory species can be exploited at key locations throughout the migration (e.g., dense aggregations of diadromous migrants passing through river mouths; Froese and Torres 1999; McDowall 1999). Highly migratory species, particularly those that cross political boundaries, can be slow to recover from exploitation due to political disagreements between the governments that have access to the fish (Caddy and Agnew 2004).

The random analysis revealed that game fish are larger than non-game fish species. Large fish tend to be targeted by anglers (Wilde and Pope 2004), and the IGFA list of record weights reflects this tendency, as there is a minimum size restriction for record submission (IGFA 2006a), and only the largest landed individual of each species is included (IGFA2006b). Our body length-matched analysis found that game fish and non-game fish were equally targeted by commercial fisheries at relatively high proportions, providing evidence for the links between body size, competing fisheries interests, and the potential for conservation risk (Olden et al. 2007). The random analysis revealed that game fish also had lower resilience and were more likely to be imperilled; however, this may be an artefact of game fish tending to be better studied and understood relative to non-game fish. Though the length-matched analysis did not find differences between game fish and non-game fish in terms of resilience or Red List status, the relatively large-bodied species in this comparison may be at a higher risk of conservation concern, yet these contrasts did not differ between groups, as might be expected. For instance, large body size can be correlated with life history characteristics that lead to imperilment, such as longer lifespan, slow growth, late age at maturity, high trophic level, as well as low natural adult mortality and relatively low annual recruitment to the adult stock (Garrod and Knights 1979; Reynolds et al. 2001; Dulvy and Reynolds 2002; Hutchings 2002; Morato et al. 2006).Further, lifespan is also closely related to age at first breeding (Roff 1988; Beverton 1992; Winemiller and Rose 1992), with long-lived species having delayed maturity (Norse and Crowder 2005). Large body size and late maturity, two traits common among species at high trophic levels, have been shown to be the best predictors of vulnerability when fish are faced with fishing pressure (Reynolds et al. 2005; Olden et al. 2007). For example, several imperilled species in the family Carcharhinidae (e.g., borneo shark [*Carcharhinus borneensis*], daggernose shark [*Isogomphodonoxyrhynchus*], Ganges shark [*Glyphis gangeticus*], smooth tooth blacktip shark [*Carcharhinus leiodon*], and speartooth shark [*Glyphis glyphis*]) tended to have large body sizes (70–720 cm), very low resilience, and high trophic status.

The intensive commercial harvest of fishes has been implicated in the widespread declines of fish populations worldwide (Christensen et al. 2003; Dulvy et al. 2003; Pauly et al. 2003; Worm et al. 2006). Recent evidence has shown that many parallels exist between recreationally and commercially targeted species (Post et al. 2002; Coleman et al. 2004; Cooke and Cowx 2004, 2006). The random analysis showed that game fish are more likely to be targeted by commercial fisheries than non-game fish. Though the length-matched analysis did not show differences between groups, it revealed that large species of both game fish and non-game fish were targeted by commercial fisheries. Together, commercial and recreational exploitation may contribute to the many interactive environmental and other anthropogenic factors that lead to conservation concerns (Rose 2005). For example, the composition of catches generated by sport and commercial fishing has been shown to be similar for blue shark (*Prionace glauca*, Carcharhinidae) populations in Atlantic Canada (Campana et al. 2006). As a result, Campana et al. (2006) found it necessary to combine the catches from recreational and commercial fisheries to obtain an accurate estimation of the impacts of fishing pressure on blue shark populations.

The random analysis revealed that 27 game fish species are considered threatened by IUCN, based solely on the species that fall in the categories of vulnerable, endangered, and critically endangered, which provides additional rationale for enhancing efforts on the study of game fish species at a global scale. Population declines of marine fishes and the inability to recover from severe commercial fishing pressure have been associated with characteristics such as large body size, slow growth rates, late age at maturity, and a long lifespan (Reynolds et al. 2001; Dulvy and Reynolds 2002; Hutchings 2002; Morato et al. 2006). Although less research has been conducted in freshwater systems, similar trends are apparent (Post et al. 2002; Allan et al. 2005; Jelks et al. 2008). Since this trend did not emerge in the length-matched comparison, clearly body size has a greater influence on conservation concern than game fish status alone.

One of the greatest challenges of conducting a global assessment contrasting game fish and non-game fish species is finding complete, quality data sets. Here, we chose FishBase because of its global scope;its use of cited, peer-reviewed data; and the fact that its data are widely used in the literature (e.g., Dulvy and Reynolds 2002; Foster and Vincent 2004).The non-game fish species included in this study were often data deficient, resulting in a not truly random selection of non-game fish because we had to rely on criteria of species having at least 75% of the required data categories in FishBase to be included in analyses. However, because many of the species contrasted in this study are data deficient, we contend that this study represents the best possible approach to contrasting game fish and non-game fish species. Until more complete data are available on these species, however, our results should be interpreted cautiously. The IUCN Red List is one of the most high-profile and trusted data sources of its kind because its classifications are based on expert input and long-term data sources. Our categorization of IUCN ranks as either threatened or not threatened is somewhat conservative: there may be species that fall into the data deficient category that may indeed be considered threatened once sufficient data are available for these species to be evaluated. As such, our classification may underrepresent the conservation concern status of both game fish and non-game fish species. Game fish may be more likely to be listed by IUCN, because more research tends to be conducted on these species relative to non-game fish, which may be more poorly understood. However, these issues cannot be resolved until more data can be obtained to further improve IUCN categorizations. The IGFA World Record List represents one of the few citable documents that takes a global approach to listing fish species that are targeted for world record catches by rod and reel. However, we recognize that the species contained in the IGFA list (see Appendix) may be biased toward North American species and may not include all possible game fish species, instead focusing on the species that are most commonly targeted by anglers.

Understanding the fundamental differences between game fish and non-game fish species, particularly in a conservation context, may become increasingly relevant as anglers begin to target species in remote locations, for which little is known about their biology and that have previously received negligible recreational fishing pressure. For example, destination tourism fisheries are being developed in many regions of the world, particularly in inland waters (Allan et al. 2005), with the promise of income for local economies even though the risks of such fisheries are largely unknown (e.g., taimen [*Hucho taimen*, Salmonidae] fisheries in Mongolia;Vander Zanden et al. 2007). Similarly, as efforts to expand aquatic protected areas increase, there is uncertainty regarding whether catch-and-release fisheries or limited harvest recreational fisheries are compatible with no-take or other types of protected areas (Cooke et al. 2006). This study characterizes fundamental differences between game fish and non-game fish characteristics at a broad scale using the best available data. These results show that there are fundamental gaps in knowledge that must be addressed to clarify these relationships. Though this study is a necessary first step, future research must focus on specific empirical comparisons between these groups to develop broad strategies for the conservation and management of game fishes at a global scale.

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From the Archives

"To Germany, beyond question, belongs the honor of discovering and carrying into practical usefulness, the art of fish culture. Upon the estate of Jacobi as has been seen, it was carried on as a branch of agriculture for nearly eighty years – from 1741-1825 – though it was nearly one hundred years before public opinion was ripe for a general acceptance of its usefulness. Recognition of fish culture was finally brought about by the zealous advocacy of men of science in France, Scotland, Bohemia and Switzerland. During the interim it appears to be certain that at no time was the practice of fish culture from a practical standpoint entirely abandoned by citizens of Germany.

Prof. G. Brown Goode, Transactions of the Tenth American Fish Cultural Association, 1881

Appendix. A list of game fish species included in this study (IGFA 2006b).

Common Name	Scientific Name	Family
Albacore	*Thunnus alalunga*	Scombridae
Alligator gar	*Lepisosteus spatula*	Lepisosteidae
Almaco jack	*Seriola rivoliana*	Carangidae
Amazon pellona	*Pellona castelneana*	Latidae
American shad	*Alosa sapidissima*	Channidae
Amur snakehead	*Channa argus warpachowskii*	Channidae
Arawana	*Osteoglossum bicirrhosum*	Osteoglossidae
Arctic char	*Salvelinus alpinus*	Salmonidae
Arctic grayling	*Thymallus arcticus*	Salmonidae
Armed snook	*Centropomus armatus*	Centropomidae
Assamese snakehead	*Channa stewartii*	Channidae
Atlantic bigeye tuna	*Thunnus obesus (Atlantic)*	Scombridae
Atlantic bonito	*Sarda sarda*	Scombridae
Atlantic cod	*Gadus morhua*	Gadidae
Atlantic halibut	*Hippoglossus hippoglossus*	Pleuronectidae
Atlantic sailfish	*Istiophorus platypterus (Atlantic)*	Istiophoridae
Atlantic salmon	*Salmo salar*	Salmonidae
Atlantic salmon (landlocked)	*Salmo salar (landlocked)*	Salmonidae
Atlantic sharpnose shark	*Rhizoprionodonterraenovae*	Carcharhinidae
Atlantic spadefish	*Chaetodipterus faber*	Ephippidae
Atlantic spearfish	*Tetrapturus belone*	Istiophoridae
Australian bass	*Macquaria colonorum*	Percichthyidae
Australian blacktip shark	*Carcharhinustilstoni*	Carcharhinidae
Australian bonito	*Sarda australis*	Scombridae
Australian sharpnose shark	*Rhizoprionodontaylori*	Carcharhinidae
Barca snakehead	*Channa barca*	Channidae
Barramundi	*Lates calcarifer*	Latidae
Barred sorubim	*Pseudoplatystoma fasciatum*	Pimelodidae
Barred sorubim	*Pseudoplatystoma fasciatum reticulatum*	Pimelodidae
Bigeye thresher	*Alopias superciliosus*	Alopiidae
Bigeye trevally	*Caranx sexfasciatus*	Carangidae
Bigmouth buffalo	*Ictiobus cyprinellus*	Catostomidae
Bignose shark	*Carcharhinusaltimus*	Carcharhinidae
Black bullhead	*Ameiurus melas*	Ictaluridae
Black crappie	*Pomoxis nigromaculatus*	Centrarchidae
Black drum	*Pogonias cromis*	Sciaenidae
Black marlin	*Makaira indica*	Istiophoridae
Black sea bass	*Centropristis striata*	Serranidae
Black skipjack	*Euthynnus lineatus*	Scombridae
Black snakehead	*Channa melasoma*	Channidae
Black snook	*Centropomus nigrescens*	Centropomidae
Black/blue rockfish	*Sebastes melanops/mystinus*	Sebastidae
Blackfin seabass	*Lateolabrax latus*	Lateolabracidae
Blackfin snook	*Centropomus medius*	Centropomidae
Blackfin tuna	*Thunnus atlanticus*	Scombridae
Blacknose shark	*Carcharhinusacronotus*	Carcharhinidae
Blackspot shark	*Carcharhinussealei*	Carcharhinidae
Blackstriped peacock	*Cichla intermedia*	Cichlidae
Blacktip reef shark	*Carcharhinusmelanopterus*	Carcharhinidae
Blacktip shark	*Carcharhinuslimbatus*	Carcharhinidae
Blue catfish	*Ictalurus furcatus*	Ictaluridae
Blue marlin (Atlantic)	*Makaira nigricans (Atlantic)*	Istiophoridae
Blue marlin (Pacific)	*Makaira nigricans (Pacific)*	Istiophoridae
Blue shark	*Prionace glauca*	Carcharhinidae
Bluefin trevally	*Caranx melampygus*	Carangidae
Bluefin tuna	*Thunnus thynnus*	Scombridae
Bluefish	*Pomatomus saltatrix*	Pomatomidae
Bluegill	*Lepomis macrochirus*	Centrarchidae
Bonefish	*Albula vulpes*	Albulidae
Bonito, Atlantic	*Sarda sarda*	Scombridae
Bonnethead	*Sphyrna tiburo*	Sphyrnidae
Borna snakehead	*Channa amphibia*	Channidae
Borneo shark	*Carcharhinusborneensis*	Carcharhinidae
Bowfin	*Amia calva*	Amiidae
Brazilian sharpnose shark	*Rhizoprionodonlalandii*	Carcharhinidae
Broadfin shark	*Lamiopsistemminckii*	Carcharhinidae
Brook trout	*Salvelinus fontinalis*	Salmonidae
Brown bullhead	*Ameiurus nebulosus*	Ictaluridae
Brown trout	*Salmo trutta*	Salmonidae
Bull shark	*Carcharhinusleucas*	Carcharhinidae
Bull trout	*Salvelinus confluentus*	Salmonidae
Burbot	*Lota lota*	Lotidae
Burmese snakehead	*Channa harcourtbutleri*	Channidae
Butterfly peacock	*Cichla ocellaris*	Cichlidae
California corbina	*Menticirrhus undulatus*	Sciaenidae
California halibut	*Paralichthys californicus*	Paralichthyidae
California yellowtail	*Seriola lalandi dorsalis*	Carangidae
Caribbean reef shark	*Carcharhinusperezii*	Carcharhinidae
Caribbean sharpnose shark	*Rhizoprionodonporosus*	Carcharhinidae
Centropomus rubens	*Centropomus rubens*	Kuhliidae
Cero mackerel	*Scomberomorus regalis*	Scombridae
Chain pickerel	*Esox niger*	Esocidae
Channa africana	*Channa africana*	Channidae
Channa bankanensis	*Channa bankanensis*	Channidae
Channa baramensis	*Channa baramensis*	Channidae
Channa burmanica	*Channa burmanica*	Channidae
Channa cyanospilos	*Channa cyanospilos*	Channidae
Channa diplogramma	*Channa diplogramma*	Channidae
Channa diplogramme	*Channa diplogramme*	Channidae
Channa insignis	*Channa insignis*	Channidae
Channa lucia	*Channa lucia*	Channidae
Channa maculata	*Channa maculata*	Channidae
Channa melanoptera	*Channa melanoptera*	Channidae
Channa nox	*Channa nox*	Channidae
Channel catfish	*Ictalurus punctatus*	Ictaluridae
Chinook salmon	*Oncorhynchus tshawytscha*	Salmonidae
Chum salmon	*Oncorhynchus keta*	Salmonidae
Cobia	*Rachycentron canadum*	Rachycentridae
Coho salmon	*Oncorhynchus kisutch*	Salmonidae
Commerson's glassy	*Centropomus ambassis*	Ambassidae
Common carp	*Cyprinus carpio*	Cyprinidae
Common snooke	*Centropomus undecimalis*	Centropomidae
Conger	*Conger conger*	Congridae
Copper shark	*Carcharhinusbrachyurus*	Carcharhinidae
Creek whaler	*Carcharhinusfitzroyensis*	Carcharhinidae
Crevalle jack	*Caranx hippos*	Carangidae
Cubera snapper	*Lutjanus cyanopterus*	Lutjanidae
Cutthroat trout	*Oncorhynchus clarki*	Salmonidae
Daggernose shark	*Isogomphodonoxyrhynchus*	Carcharhinidae
Dentex	*Dentex dentex*	Sparidae
Dogtooth tuna	*Gymnosarda unicolor*	Scombridae
Dolly Varden	*Salvelinus malma*	Salmonidae
Dolphinfish	*Coryphaena hippurus*	Coryphaenidae
Doublespotted queenfish	*Scomberoides lysan*	Carangidae
Dusky shark	*Carcharhinusobscurus*	Carcharhinidae
Dwarf snakehead	*Channa gachua*	Channidae
Eastern Pacific bonito	*Sarda chilensis chilensis*	Scombridae
Emperor snakehead	*Channa marulioides*	Channidae
European bass	*Dicentrarchus labrax*	Moronidae
European grayling	*Thymallus thymallus*	Salmonidae
European pollack	*Pollachius pollachius*	Gadidae
European seabass	*Centropomus lupus*	Moronidae
Fat snook	*Centropomus parallelus*	Centropomidae
Finetooth shark	*Carcharhinusisodon*	Carcharhinidae
Flathead catfish	*Pylodictis olivaris*	Ictaluridae
Florida gar	*Lepisosteus platyrhincus*	Lepisosteidae
Freshwater drum	*Aplodinotus grunniens*	Lepisosteidae
Gag grouper	*Mycteroperca microlepis*	Serranidae
Galapagos shark	*Carcharhinusgalapagensis*	Carcharhinidae
Ganges shark	*Glyphisgangeticus*	Carcharhinidae
Giant sea bass	*Stereolepis gigas*	Polyprionidae
Giant snakehead	*Channa micropeltes*	Channidae
Giant tigerfish	*Hydrocynus goliath*	Alestiidae
Giant trahira	*Hoplias macrophthalmus*	Erythrinidae
Giant trevally	*Caranx ignobilis*	Carangidae
Golden trout	*Oncorhynchus aguabonita*	Salmonidae
Goliath grouper	*Epinephelus itajara*	Serranidae
Graceful shark	*Carcharhinusamblyrhynchoides*	Carcharhinidae
Grass carp	*Ctenopharyngodon idellus*	Cyprinidae
Great barracuda	*Sphyraena barracuda*	Sphyraenidae
Great hammerhead	*Sphyrna mokarran*	Sphyrnidae
Great snakehead	*Channa marulius*	Channidae
Greater amberjack	*Seriola dumerili*	Carangidae
Green sunfish	*Lepomis cyanellus*	Centrarchidae
Grey reef shark	*Carcharhinusamblyrhynchos*	Carcharhinidae
Grey sharpnose shark	*Rhizoprionodonoligolinx*	Carcharhinidae
Guianan snook	*Centropomus mexicanus*	Centropomidae
Guinean barracuda	*Sphyraena afra*	Sphyraenidae
Hardnose shark	*Carcharhinusmacloti*	Carcharhinidae
Horse-eye jack	*Caranx latus*	Carangidae
Huchen	*Hucho hucho*	Salmonidae
Inconnu	*Stenodus leucichthys*	Salmonidae
Irrawaddy river shark	*Glyphissiamensis*	Carcharhinidae
Japanese parrotperch	*Oplegnathus fasciatus*	Oplegnathidae
Japanese seabass	*Lateolabrax japonicus*	Lateolabracidae
Kahawai	*Arripis trutta*	Arripidae
Kawakawa	*Euthynnus affinis*	Scombridae
Kelp bass	*Paralabrax clathratus*	Serranidae
King mackerel	*Scomberomorus cavalla*	Scombridae
Kokanee	*Oncorhynchus nerka*	Esocidae
Lake trout	*Salvelinus namaycush*	Salmonidae
Lake whitefish	*Coregonus clupeaformis*	Salmonidae
Largemouth bass	*Micropterus salmoides*	Centrarchidae

Common Name	Scientific Name	Family
Large-toothed cardinalfish	*Centropomus macrodon*	Apogonidae
Leerfish (Garrick)	*Lichia amia*	Carangidae
Lemon shark	*Negaprionbrevirostris*	Carcharhinidae
Lingcod	*Ophiodon elongatus*	Hexagrammidae
Little tunny	*Euthynnus alletteratus*	Scombridae
Longbill spearfish	*Tetrapturus pfluegeri*	Istiophoridae
Longfin mako	*Isurus paucus*	Lamnidae
Longfin mako	*Isurus alatus*	Lamnidae
Longjaw bonefish	*Albula forsteri*	Albulidae
Longnose gar	*Lepisosteus osseus*	Lepisosteidae
Longtail tuna	*Thunnus tonggol*	Scombridae
Madai	*Pagrus major*	Sparidae
Meagre	*Argyrosomus regius*	Sciaenidae
Mexican snook	*Centropomus poeyi*	Centropomidae
Milk shark	*Rhizoprionodonacutus*	Carcharhinidae
Mullet snapper	*Lutjanus aratus*	Lutjanidae
Muskellunge	*Esox masquinongy*	Esocidae
Mutton snapper	*Lutjanus analis*	Lutjanidae
Narrowbarred mackerel	*Scomberomorus commerson*	Scombridae
Nembwe	*Serranochromis robustus*	Cichlidae
Nervous shark	*Carcharhinuscautus*	Carcharhinidae
Night shark	*Carcharhinussignatus*	Carcharhinidae
Nile perch	*Centropomus niloticus*	Latidae
Nile perch	*Lates niloticus*	Moronidae
Northern pike	*Esox lucius*	Characidae
Oceanic whitetip shark	*Carcharhinuslongimanus*	Carcharhinidae
Ocellated snakehead	*Channa pleurophthalma*	Channidae
Orange-spotted snakehead	*Channa aurantimaculata*	Channidae
Oscar	*Astronotus ocellatus*	CyNodontidae
Pacific bigeye tuna	*Thunnus obesus (Pacific)*	Scombridae
Pacific bonito	*Sarda chiliensis lineolata*	Scombridae
Pacific cod	*Gadus macrocephalus*	Gadidae
Pacific crevalle Jack	*Caranx caninus*	Carangidae
Pacific cubera snapper	*Lutjanus novemfasciatus*	Lutjanidae
Pacific halibut	*Hippoglossus stenolepis*	Pleuronectidae
Pacific sailfish	*Istiophorus platypterus (Pacific)*	Istiophoridae
Pacific sharpnose shark	*Rhizoprionodonlongurio*	Carcharhinidae
Pacific sierra mackerel	*Scomberomorus sierra*	Scombridae
Panaw snakehead	*Channa panaw*	Channidae
Papuan black snapper	*Lutjanus goldiei*	Pimelodidae
Payara	*Hydrolicus scomberoides*	Cichlidae
Pelagic thresher	*Alopias pelagicus*	Alopiidae
Permit	*Trachinotus falcatus*	Carangidae
Pigeye shark	*Carcharhinusamboinensis*	Carcharhinidae
Pink salmon	*Oncorhynchus gorbuscha*	Salmonidae
Plain bonito	*Orcynopsis unicolor*	Scombridae
Pollock	*Pollachius virens*	Gadidae
PompaNo, African	*Alectis ciliaris*	Carangidae
Pondicherry shark	*Carcharhinushemiodon*	Carcharhinidae
Porbeagle shark	*Lamna nasus*	Lamnidae
Rainbow runner	*Elagatis bipinnulata*	Carangidae
Rainbow snakehead	*Channa bleheri*	Channidae
Rainbow trout	*Oncorhynchus mykiss*	Salmonidae
Red drum	*Sciaenops ocellatus*	Sciaenidae
Red grouper	*Epinephelus morio*	Serranidae
Red piranha	*Serrasalmus natterati*	Catostomidae
Red snapper	*Lutjanus campechanus*	Lutjanidae
Redbreast sunfish	*Lepomis auritus*	Centrarchidae
Redear sunfish	*Lepomis microlophus*	Salmonidae
Redtail catfish	*Phractocephalus hemioliopterus*	Pimelodidae
Rock bass	*Ambloplites rupestris*	Centrarchidae
Rock flagtail	*Centropomus rupestris*	Kuhliidae
Roosterfish	*Nematistius pectoralis*	Nematistiidae
Roundjaw bonefish	*Albula glossodonta*	Albulidae
Sandbar shark	*Carcharhinusplumbeus*	Carcharhinidae
Sauger	*Stizostedion canadense*	Clupeidae
Scalloped bonnethead	*Sphyrna corona*	Sphyrnidae
Scalloped hammerhead	*Sphyrna lewini*	Sphyrnidae
Scoophead	*Sphyrna media*	Sphyrnidae
Sharpjaw bonefish	*Albula neoguinaica*	Albulidae
Sharptooth catfish	*Clarias gariepinus*	Clariidae
Shoal bass	*Micropterus coosae*	Centrarchidae
Shortbill spearfish	*Tetrapturus angustirostris*	Istiophoridae
Shortened redhorse	*Moxostoma macrolepidotum*	Catostomidae
Shortfin mako	*Isurus oxyrinchus*	Lamnidae
Shortnose gar	*Lepisosteus platostomus*	Lepisosteidae
Sicklefin lemon shark	*Negaprionacutidens*	Carcharhinidae
Silky shark	*Carcharhinusfalciformis*	Carcharhinidae
Silver redhorse	*Moxostoma anisurum*	Salmonidae
Silvertip shark	*Carcharhinusalbimarginatus*	Carcharhinidae
Skipjack tuna	*Katsuwonus pelamis*	Scombridae
Sliteye sharkead	*Loxodonmacrorhinus*	Carcharhinidae

Common Name	Scientific Name	Family
Small snakehead	*Channa asiatica*	Channidae
Small snakehead	*Channa formosana*	Channidae
Small snakehead	*Channa ocellata*	Channidae
Smalleye hammerhead	*Sphyrna tudes*	Sphyrnidae
Smallmouth bass	*Micropterus dolomieu*	Centrarchidae
Smallmouth buffalo	*Ictiobus bubalus*	Catostomidae
Smalltail shark	*Carcharhinusporosus*	Carcharhinidae
Smooth hammerhead	*Sphyrna zygaena*	Sphyrnidae
Smoothtooth blacktip	*Carcharhinusleiodon*	Carcharhinidae
Snakehead	*Channa argus*	Channidae
Snakehead	*Channa obscura*	Channidae
Snakehead murrel	*Channa striata*	Channidae
Sockeye salmon	*Oncorhynchus nerka (landlocked)*	Percidae
Southern bluefin tuna	*Thunnus maccoyi*	Scombridae
Southern yellowtail	*Seriola lalandi lalandi*	Carangidae
Spadenose shark	*Scoliodonlaticaudus*	Carcharhinidae
Spanish mackerel	*Scomberomorus maculatus*	Scombridae
Speartooth shark	*Glyphisglyphis*	Carcharhinidae
Speckled peacock	*Cichla temensis*	Pristigasteridae
Spinner shark	*Carcharhinusbrevipinna*	Carcharhinidae
Spottail shark	*Carcharhinussorrah*	Carcharhinidae
Spotted bass	*Micropterus punctulatus*	Centrarchidae
Spotted gar	*Lepisosteus oculatus*	Salmonidae
Spotted parrotperch	*Oplegnathus punctatus*	Oplegnathidae
Spotted seatrout	*Cynoscion nebulosus*	Sciaenidae
Spotted snakehead	*Channa punctata*	Channidae
Spotted sorubim	*Pseudoplatystoma corruscans*	Pimelodidae
Squirefish snapper	*Pagrus auratus*	Sparidae
Striped bass	*Morone saxatilis*	Moronidae
Striped bass (landlocked)	*Morone saxatilis (landlocked)*	Moronidae
Striped bonito	*Sarda orientalis*	Scombridae
Striped marlin	*Tetrapturus audax*	Istiophoridae
Summer flounder	*Paralichthys dentatus*	Paralichthyidae
Swordfish	*Xiphias gladius*	Xiphiidae
Swordspine snook	*Centropomus ensiferus*	Centropomidae
Taimen	*Hucho taimen*	Characidae
Talang queenfish	*Scomberoides commersonnianus*	Carangidae
Tambaqui	*Colossoma macropomum*	Cyprinidae
Tarpon	*Megalops atlanticus*	Megalopidae
Tarpon snook	*Centropomus pectinatus*	Centropomidae
Tautog	*Tautoga onitis*	Labridae
Tench	*Tinca tinca*	Alestiidae
Thintail thresher	*Alopias vulpinus*	Alopiidae
Threadfin bonefish	*Albula nemoptera*	Albulidae
Threadfin, king	*Polydactylus macrochir*	Polynemidae
Tiger cardinal	*Centropomus arabicus*	Apogonidae
Tiger shark	*Galeocerdo cuvier*	Carcharhinidae
Tiger sorubim	*Pseudoplatystoma tigrinum*	Pimelodidae
Tigerfish	*Hydrocynus vittatus*	Alestiidae
Tope shark	*Galeorhinus galeus*	Triakidae
Tripletail	*Lobotes surinamensis*	Lobotidae
Union snook	*Centropomus unionensis*	Centropomidae
Wahoo	*Acanthocybium solandri*	Scombridae
Walking snakehead	*Channa orientalis*	Channidae
Walleye	*Stizostedion vitreum*	Percidae
Warmouth	*Lepomis gulosus*	Centrarchidae
Weakfish	*Cynoscion regalis*	Sciaenidae
Wels	*Silurus glanis*	Siluridae
White bass	*Morone chrysops*	Moronidae
White catfish	*Ameiurus catus*	Ictaluridae
White crappie	*Pomoxis annularis*	Centrarchidae
White marlin	*Tetrapturus albidus*	Istiophoridae
White perch	*Morone americana*	Percidae
White seabass	*Atractoscion nobilis*	Sciaenidae
White shark	*Carcharodon carcharias*	Lamnidae
White snook	*Centropomus viridis*	Centropomidae
Whitecheek shark	*Carcharhinusdussumieri*	Carcharhinidae
Whitefin hammerhead	*Sphyrna couardi*	Sphyrnidae
Whitefish, mountain	*Prosopium williamsoni*	Salmonidae
Whitefish, round	*Prosopium cylindraceum*	Salmonidae
Whitenose shark	*Nasolamiavelox*	Carcharhinidae
Whitetip reef shark	*Triaenodonobesus*	Carcharhinidae
Winghead shark	*Eusphyra blochii*	Sphyrnidae
Yawa	*Albula argentea*	Albulidae
Yellow bass	*Morone mississippiensis*	Moronidae
Yellow bullhead	*Ameiurus natalis*	Ictaluridae
Yellow perch	*Perca flavescens*	Esocidae
Yelloweye rockfish	*Sebastes ruberrimus*	Sebastidae
Yellowfin snook	*Centropomus robalito*	Centropomidae
Yellowfin tuna	*Thunnus albacares*	Scombridae
Yellowtail snapper	*Ocyurus crysurus*	Lutjanidae
Zander	*Stizostedion lucioperca*	Percidae

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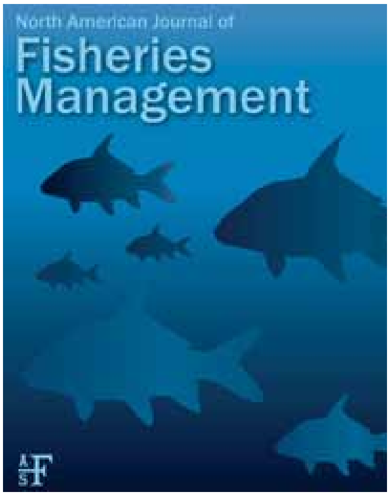

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[Management Brief] Movement and Survival of Brown Trout and Rainbow Trout in an Ozark Tailwater River. *Jeffrey W. Quinn and Thomas J. Kwak.* 31: 299–304.

Comparing Size, Movement, and Habitat Selection of Wild and Streamside-Reared Lake Sturgeon. *Kevin A. Mann, J. Marty Holtgren, Nancy A. Auer, and Stephanie A. Ogren.* 31: 305–314.

[Management Brief] Radiotelemetry to Estimate Stream Life of Adult Chum Salmon in the McNeil River, Alaska. *Joshua M. Peirce, Edward O. Otis, Mark S. Wipfli, and Erich H. Follmann.* 31: 315–322.

The Impact of Different Performance Measures on Model Selection for Fraser River Sockeye Salmon. *Jonathan W. Cummings, Merran J. Hague, David A. Patterson, and Randall M. Peterman.* 31: 323–334.

[Management Brief] A Portable Electronarcosis System for Anesthetizing Salmonids and Other Fish. *J. Michael Hudson, Jeffrey R. Johnson, and Boyd Kynard.* 31: 335–339.

Evaluation of Hypotheses for Describing Temporal Trends in Atlantic Salmon Parr Densities in Northeast U.S. Rivers. *Tyler Wagner and John A. Sweka.* 31: 340–351.

Movements of Radio- and Acoustic-Tagged Adult Koi Carp in the Waikato River, New Zealand. *Adam J. Daniel, Brendan J. Hicks, Nicholas Ling, and Bruno O. David.* 31: 352–362.

Evaluating Benchmarks of Population Status for Pacific Salmon. *Carrie A. Holt and Michael J. Bradford.* 31: 363–378.

Resolving Some of the Complexity of a Mixed-Origin Walleye Population in the East Basin of Lake Erie Using a Mark–Recapture Study. *Yingming Zhao, Donald W. Einhouse, and Thomas M. MacDougall.* 31: 379–389.

Comparison of Boat Electrofishing, Trawling, and Seining for Sampling Fish Assemblages in Iowa's Nonwadeable Rivers. *Travis E. Neebling and Michael C. Quist.* 31: 390–402.

Accurate Estimation of Salmonid Abundance in Small Streams using Nighttime Removal Electrofishing: an Evaluation using Marked Fish. *W. Carl Saunders, Kurt D. Fausch, and Gary C. White.* 31: 403–415.

[Erratum] Survival of Discarded Sublegal Atlantic Cod in the Northwest Atlantic Demersal Longline Fishery. *Henry O. Milliken, Marianne Farrington, Tom Rudolph, and Melissa Sanderson* (volume 29:985–995). 31: 416.

[Erratum] Proposed Standard Weight (Ws) Equation and Standard Length Categories for Suwannee Bass. *Timothy F. Bonvechio, Kimberly I. Bonvechio, and Richard L. Cailteux* (volume 30:983–988). 31: 417.

AMERICAN FISHERIES SOCIETY

www.fisheries.org

New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World

2010 ANNUAL REPORT

MISSION

The mission of the AFS is to advance sound science, promote professional development, and disseminate science-based fisheries information for the global protection, conservation, and sustainability of fisheries resources and aquatic ecosystems. The Society adopted a Strategic Plan for 2010–2014 with three overarching goals: (1) Global Fisheries Leadership — AFS will be a global leader providing information and technical resources for the sustainability and conservation of fisheries resources; (2) Education/Continuing Education — AFS will facilitate life-long learning through world-class educational resources at all academic levels and provide training for practicing professionals in all branches of fisheries and aquatic sciences; and (3) Value of Membership — AFS will serve its members and fisheries, aquaculture, and aquatic science constituencies to fulfill the mission of the Society. The members of the AFS are drawn together by a common interest in pursuing this mission and the goals of the Society. Our challenge is how to carry out the mission in an ever-changing world.

GLOBAL FISHERIES LEADERSHIP THEME FOR THE YEAR

The theme for the 2010–2011 year and the 2011 Annual Meeting in Seattle is "New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World". The spatial and temporal scales at which we work are advancing beyond individual lakes or stream segments to large watersheds, whole oceans, and world climate with changes measured not just in years or decades but in centuries and millennia. The array of disciplines contributing to understanding and management of fisheries is advancing far beyond the biological sciences to include sociology, economics, geography, climatology, and many other fields. Technological advances are taking place at such a rapid rate that they are defining how science is conducted, information is exchanged, and business is carried out. Concomitant with all of this change, there is increasing diversity in the membership of the Society with people of diverse cultural backgrounds, educations, employment, and nationalities contributing to the mission of the Society. The AFS has the opportunity to lead the way in this changing world by advancing the principles of sound science, promoting professional development, and disseminating science-based information.

ANNUAL MEETING

The Annual Meeting addresses this year's theme in many ways. The Plenary Session kicks off with an invocation by the local Muckleshoot Tribe and welcoming remarks by Dow Constantine, King County Executive. Four prominent professionals will then address various aspects of the theme: Randall Peterman, Professor, School of Resource Management, Simon Fraser University; Billy Frank, Jr., Chairman, Northwest Indian Fisheries Commission; Robert Lackey, Professor of Fisheries and Adjunct Professor of Political Science, Oregon State University; and Jesse Trushenski, Assistant Professor, Department of Zoology, Southern Illinois University –Carbondale. Each speaker provides insight on how to lead in a changing world. The Plenary Session is followed by the largest and most varied program in the history of the AFS. The program includes an unprecedented 94 symposia. Each day will have 24–29 concurrent sessions of symposia and contributed papers focused on diverse critical topics of global, national, and regional interest. The oral sessions complement more than 450 posters on a similar array of topics.

WORLD COUNCIL OF FISHERIES SOCIETIES

The AFS continues to be an active member of the World Council of Fisheries Societies and is preparing for the 6th World Fisheries Congress in Edinburgh, Scotland in 2012. The society is organizing a session on natural and anthropogenic catastrophic events, their effects on fisheries and aquatic systems, and the management of such events.

COALITION OF NATURAL RESOURCE SOCIETIES

We continue to work at building up the Coalition of Natural Resource Societies in partnership with The Wildlife Society, the Society of American Foresters, and the Society for Range Management. A strong collaborative effort is occurring with the joint development of a conference addressing an issue of common interest, the education of natural resource professionals. The conference will occur in late September 2011 in Denver.

NATIONAL FISH HABITAT ACTION PLAN

The Society continues to partner with stakeholders and resource management agencies to support and invigorate work to achieve the National Fish Habitat Action Plan. The AFS is represented on the National Fish Habitat Action Plan Board by Past President, Stan Moberly.

POLICY STATEMENTS

Policy statements are the principal instrument used by the AFS in addressing environmental issues. These are statements of principle about resource topics that explain and justify the Society's perspective or attitude in largely philosophical terms. Policy statements are developed through an arduous vetting process guided by the Resource Policy Committee and approved by both a vote of the Governing Board and AFS members. This year the Society approved a policy statement on Climate Change and Fisheries. We are currently working on policy statements involving lead in sport fishing tackle and the need for an immediate-release anesthetic/sedative for use in fisheries, as well as revision of several policy statements previously approved.

EDUCATION/CONTINUING EDUCATION

Educating New Professionals

We continue the Hutton Junior Fisheries Biology Program, a summer mentoring program for high school students, particularly students underrepresented in the fisheries profession. For the second year, a program for Native Peoples undergraduate students has been funded by the U.S. Fish and Wildlife Service and administered by AFS that will enable attendance at our Annual Meeting.

Mentoring Young Professionals

The new mentoring program to encourage leadership within the Society among young professionals continued in its second year. Young professionals who have expressed interest in AFS governance and leadership have been invited to participate for one year in Governing Board activities.

Continuing Education

The Society continues to offer an array of continuing education courses in conjunction with its meetings. These courses provide not only educational opportunities for practicing professionals, but also continuing education credit for those seeking renewal of AFS certification as fisheries professionals. A special committee developed strategies for distance education offerings of continuing education this year and the first opportunity for distance learning is offered in conjunction with the 2011 Annual Meeting with the course, Leadership at All Levels in AFS, organized by Dirk Miller.

VALUE OF MEMBERSHIP

Website Development

The Society continues the objective of delivering the best possible information to members via its website. The Electronic Services Advisory Board is conducting a survey and preparing a report to the Governing Board with guidance as to how best to allocate funds to this objective.

Certified Fisheries Professionals

The objectives of the AFS professional certification program are (1) to provide agencies, organizations, courts, and the public with a definitive minimum standard of experience and education for fisheries professionals and; (2) foster broader recognition of fisheries professionals as being well-educated and experienced. Less than 20% of AFS members are certified. We are concerned about the limited participation and the Membership Concerns Committee is conducting surveys of certified and uncertified AFS members to gather information that may be used to improve the program and encourage wider participation.

Virtual Attendance at Meetings

The AFS recognizes than most members are unable to attend Annual Meetings. While nothing can replace physical attendance at meetings, technical advances make it possible for members to engage in virtual attendance. Technology is making it possible for members to see the Plenary Session, Business Meeting, and five important symposia at the 2011 Annual Meeting. These pilot efforts will undoubtedly lead to more expansive coverage of meetings in the future.

MEMBERSHIP

The AFS is the oldest and largest professional society for fisheries professionals. We have a vibrant Society with a stable membership of about 9,000 people. Membership by students and young professionals is increasing, indicating sound recruitment into our ranks and the potential for growth into the future. We are a fiscally sound Society that has weathered the economic recession. There is substantial promise for the future as we continue to pursue the mission of the Society.

Wayne A. Hubert
President

Gus Rassam
Executive Director

BRAVO PITTSBURGH – HELLO SEATTLE!

Kudos to the program committees who set up local arrangements for the AFS 140th Annual Meeting, held in Pittsburgh on September 12–16, 2010. Four days focused on "Merging Deeper Currents" took place at the David L. Lawrence Convention Center – the world's first "green" convention center. Plenary speakers included Ian Cowx (director of the University of Hull International Fisheries Institute), Jane Lubchenco (administrator of the National Oceanic and Atmospheric Administration), Larry Schweiger (president and chief executive officer of the National Wildlife Federation), and Melissa Wuellner (assistant professor and distance education coordinator in the Department of Wildlife and fisheries Science at South Dakota State University). Cowx discussed the need for us to examine our shifting roles in science, regarding environmental and sustainability issues in the management of fisheries. Lucchenco called on attendees to work on real world problems in the area of international fisheries, now that a constant stream of data is available. Schweiger suggested that discernment was needed for the barrage of environmental information and data being offered, but that we needed to focus on getting out of our comfort level and making the world a better place for our children. Wuellner discussed the difference between new fisheries professionals in comparison to veteran professionals, as well as how to bring new members aboard and retain them. We look forward to our next meeting, to be held this September in Seattle, where over 4,000 papers will be presented and a breaking attendance record is expected. (afs2011.org)

WORLD FISHERIES CONGRESS IN 2012

AFS continues to be a leader in the World Council of Fisheries Societies, as it helps prepare for the 6th World Fisheries Congress, to be held May 7–11, 2012 in Edinburgh, Scotland (6thwfc2012.com). The theme of the meeting will be "Sustainable Fisheries in a Changing World," and AFS has taken on the responsibility for two of the major sessions. The World Fisheries Congress 2012 aims to bring together a wide cross-section of scientists, non-governmental organizations, managers, and policy-makers together with those for whom their livelihoods and businesses are directly affected by the global trade and sustainability on fisheries products. This Congress will also focus on how we can provide a broad spectrum of solutions that will achieve future sustainable fisheries. The Local Scientific Steering Committee is proud to announce Professor Sir John Beddington CMG FRS, Professor Ray Hilborn, and Mike Mitchell to be Keynote Speakers' at the 6th World Fisheries Congress.

THE JAPANESE TSUNAMI

AFS responded to the tsunami disaster in Japan with financial assistance to students, and, in return, received a letter of thanks from the Imperial Palace in Tokyo, published in the April edition of Fisheries (www.fisheries.org/afs/publications.html).

CLIMATE CHANGE POLICY STATEMENT

Clearly climate warming is not going away, and finally AFS has passed our Climate Change Policy Statement to recognize the effects of climate change on aquatic organisms. The AFS Climate Change Policy Statement is accompanied by a background paper (fisheries.org/afs/docs/policy_33f.pdf) reflecting several years of concerted effort by the Resource Policy Committee. The background paper summarizes projected impacts to major North American ecosystems from the oceans to the mountains, and serves as the basis for a series of recommended actions to benefit fish and fish habitat. Although some might think our policy statement took a long time – AFS began working on this five years ago – its lateness was deliberate. AFS has only passed 33 policy statements in its entire history (all 33 available at: fisheries.org/afs/policy_statements.html). AFS bases policy statements on science and as many points of view as possible. We have extremely active committees at the level of the parent society, with over 300 volunteers participating. Large and active committees include: Board of Professional Certification, Electronic Services Advisory Board, Continuing Education, External Affairs, Nominating, Publications Awards, Publications Overview, and Resource Policy, just to name a few. Kudos to our Resources Policy Committee that has shepherded this work.

OUR PARTNERSHIP WITH TAYLOR & FRANCIS

Since 1872, AFS has been publishing the best and most complete scientific information on fisheries, fulfilling its primary mission to disseminate scientific information to scientists and professionals around the world. Over the years, the AFS Journal program has provided a major share of the net revenues of the Society, thus allowing support for non-revenue-generating programs such as public information, policy development, and various scholarship and educational opportunities. While volunteers (editors and reviewers) do the essential quality control in our journals through their dedication to peer review, our staff working with an outside vendor prepare the journals for final publication. Through 2010, this vendor/partner, with one exception, was Allen Press. However, as of 2011, AFS began publishing all of its journals through a partnership with Taylor and Francis. The contents of our publications continue to be fully vetted and scrutinized by the same editorial team and structure that AFS has always employed, thus assuring the continuous integrity and highest quality of our journals. Now, our journals are being shown at various North American and international meetings, and there will continue to be enhancements to our legacy database, Fisheries InfoBase, through adding the non-science articles of the earliest issues of the Transactions. We still use Allen Press to print journals, but Taylor and Francis oversees the production, and has taken us into a much higher realm of marketing. Our transition to Taylor & Francis has now been completed with very few bumps in the road, and exceptional new portals for accessing journals and submitting manuscripts. Our journals are doing well, with high numbers of submissions and quality science published. Fisheries has a new, attractive, up-to-date format, with additions such as quotes from historic figures.

AFS WEB SITE: WWW.FISHERIES.ORG

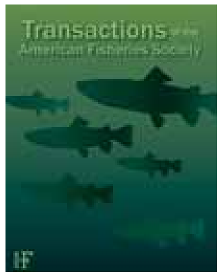
Visit www.fisheries.org for the latest on fisheries science and the profession. Subscribe to the free Contents Alert e-mail service or search for your colleagues by using the membership directory online.

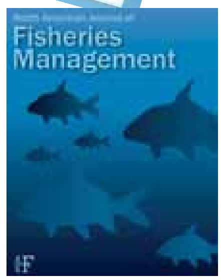
The Fisheries InfoBase now includes all AFS journals back to 1870, including the complete contents of all issues of *Fisheries*.

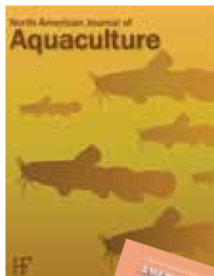
AFS MAGAZINE: *FISHERIES*

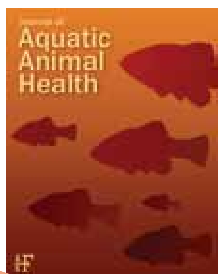
The AFS membership journal, *Fisheries*, offers up-to-date information on fisheries science, management, and research, as well as AFS and professional activities. Featuring peer-reviewed scientific articles, analysis of national and international policy, chapter news, job listings, interviews with prominent professionals (as well as new members), archived content dating back to the beginning of AFS, and more. *Fisheries* gives AFS members the professional edge in their careers as researchers, regulators, and managers of local, national, and world fisheries. *Fisheries* is available to members online at www.fisheries.org.

AFS JOURNALS









- TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY, bimonthly, Volume 140
- NORTH AMERICAN JOURNAL OF AQUACULTURE, quarterly, Volume 73
- NORTH AMERICAN JOURNAL OF FISHERIES MANAGEMENT, bimonthly, Volume 31
- JOURNAL OF AQUATIC ANIMAL HEALTH, quarterly, Volume 23
  (Journals are also available to subscribing members online at http://afsjournals.org)
- MARINE AND COASTAL FISHERIES JOURNAL
  Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, is an international venue for studies of marine, coastal, and estuarine fisheries. Edited by a distinguished and international panel of scientists headed by Dr. Donald Noakes (Thompson Rivers University, British Columbia, Canada), this journal promotes the wide dissemination of scientific research through its open access, online format. The journal encourages contributors to identify and address challenges in population dynamics, assessment techniques and management approaches, fish and shellfish biology, human dimensions and socioeconomics, and ecosystem metrics to improve fisheries science in general and make informed predictions and decisions. The journal is now accepting submissions. For more information, please visit www.fisheries.org/mcf or contact the Editor-in-Chief, Dr. Donald Noakes, (dnoakes@tru.ca).

RECENT AND UPCOMING TITLES

AFS Books

- *Invasive Asian Carps in North America*
- *Sustainable Fisheries: Multi-Level Approaches to a Global Problem*
- *Inland Fisheries Management in North America, Third Edition*
- *Case Studies in Fisheries Conservation and Management: Applied Critical Thinking and Problem Solving*
- *Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens (Blue Book, 2010 Edition)*
- *Community Ecology of Stream Fishes: Concepts, Approaches, and Techniques*
- *Planning and Standard Operating Procedures for the Use of Rotenone in Fish Management*
- *Pacific Salmon: Ecology and Management of Western Alaska's Populations*
- *Standard Methods for Sampling North American Freshwater Fishes*
- *Challenges for Diadromous Fishes in a Dynamic Global Environment*

SOCIETY AWARDS

AWARD OF EXCELLENCE
Roy Stein, Ohio State University

PRESIDENT'S FISHERY CONSERVATION AWARD
Non-Member Category- Eglin Air Force Base, Natural Resources Section

WILLIAM E. RICKER RESOURCE CONSERVATION AWARD
William Walter Fox, Jr., World Wildlife Fund

CARL R. SULLIVAN FISHERY CONSERVATION AWARD
Charlton Bonham, Trout Unlimited and **Richard Roos-Collins,** Natural Heritage Institute

MERITORIOUS SERVICE AWARD
Fred Harris, retired, North Carolina Wildlife Resources Commission

THE EMMELINE MOORE PRIZE
Christine M. Moffitt, University of Idaho

EXCELLENCE IN PUBLIC OUTREACH AWARD
Not awarded this year.

DISTINGUISHED SERVICE AWARD
Gwen White
Charlie Moseley

OUTSTANDING CHAPTER AWARD.
Large: **Washington-British Columbia Chapter**
Small**: Indiana Chapter**

OUTSTANDING STUDENT SUBUNIT AWARD
Lake Superior State University Student Subunit

EXCELLENCE IN FISHERIES EDUCATION
Thomas P. Quinn, University of Washington

GOLDEN MEMBERSHIP AWARDS: THE CLASS OF 1961
Recognizes individuals who have been AFS members for fifty years.

Henry Booke, Gerald Bouck, William Dieffenbach, Neal Foster, William Gould, Bobby Grinstead, Joe Herring, Donald Hoss, James Kempinger, James McCleave, Joseph Nelson, Roland Reagan, William Shelton, Clair Stalnaker, Arden Trandahl, Graden West

SKINNER AWARD
The John E. Skinner Memorial Fund was established to provide monetary travel awards for deserving graduate students or exceptional undergraduate students to attend the AFS Annual Meeting.

Recipients:
Elissa Buttermore, North Carolina State University
Michael Colvin, Iowa State University
Devin DeMario, Penn State University
Michael Gatlin, Oklahoma State University
Zachary Penney, University of Idaho
Joshua Perkin, Kansas State University
Joshua Raabe, North Carolina State University
Kenneth Riley, East Carolina University
Patrick Shirey, University of Notre Dame
Kelly Stockton, University of Idaho

Honorable Mention:
Corey DeBoom, University of Illinois
David Janetski, University of Notre Dame
Bonnie Mulligan, Southern Illinois University
Catherine Murphy, Louisiana State University
Stephanie Shaw, South Dakota State University

J. FRANCES ALLEN SCHOLARSHIP
Winner: Marie-Ange Gravel, Carleton University
Runner-up: Neala W. Kendall, University Of Washington

STEVEN BERKELEY MARINE CONSERVATION FELLOWSHIP
Winner: Kristina Cammen
Honorable Mentions: Justin Perrault and Hollie Putnam

STUDENT WRITING CONTEST
Winner: Erin Loury, Moss Landing Marine Labs
"Fishing with a Mission: Collaborating to Monitor California's Marine Protected Areas"

1st Runner-up: Daniel James, South Dakota State University
"Rock Snot and Boulder Boogers"

2nd Runner-up: D.J. Dembkowski, Mississippi State University
"Fish Species Richness in Oxbow Lakes"

2009 BEST PAPER AWARDS
Mercer Patriarche Award for the Best Paper in the North American Journal of Fisheries Management
Danielle Ameen Reich and Joseph Thomas DeAlteris
A Simulation Study of the Effects of Spatially Complex Population Structure for Gulf of Main Atlantic Cod
North American Journal of Fisheries Management 29: 116-126.

Robert L. Kendall Best Paper in Transactions of the American Fisheries Society
William H. Satterthwaite , Michael P. Beakes, Erin M. Collins, David R. Swank, Joseph E. Merz, Robert G. Titus, Susan M. Sogard and Marc Mangel
Steelhead Life History on California's Central Coast: Insights from a State-Dependent Model
Transactions of the American Fisheries Society 138:532-548

Best Paper in the Journal of Aquatic Animal Health
Banu Elibol-Flemming, Geoffrey C. Waldbieser, William R. Wolters, Carolyn R. Boyle, and Larry A. Hanson
Expression Analysis of Selected Immune-Relevant Genes in Channel Catfish during Edwardsiella ictaluri Infection
Journal of Aquatic Animal Health 2009; 21:23-25

Best Paper in the North American Journal of Aquaculture
Randy W. Penney, M. Jeanne Hart, P. Lynn Lush, and Christopher C. Parrish
Effect of Photoperiod Advancement of Atlantic Cod Spawning on Egg Size and Biochemistry
North American Journal of Aquaculture 2009; 71: 107-115.

SECTION AWARDS

EQUAL OPPORTUNITIES SECTION
Mentor Award: Kelley D. Smith

EDUCATION SECTION
AFS Best Student Poster Award at 2009 Annual Meeting, Nashville, Tennessee
Justin VanDeHey

Honorable Mentions:
Christian Imholt; Clint Lloyd

AFS/SEA Grant Best Student Paper at 2009 Annual Meeting, Nashville, Tennessee
Stacy Beharry
Honorable Mentions:
Ryan Utz; Duncan Elkins

ESTUARIES SECTION
Student Travel Award:
Alicia Landi, University of Connecticut
Ken Riley, East Carolina University
Amy Then, College of William and Mary
Nancy Foster Habitat Conservation Award: Charles Rabeni

FISHERIES INFORMATION AND TECHNOLOGY SECTION
Best Student Poster Award at 2010 Annual Meeting, Pittsburgh, Pennsylvania
Winner: Alicia Landi, "Estimation of wave energy using fetch and wind data at horseshoe crab spawning beaches along the Connecticut coast."

FISHERIES MANAGEMENT SECTION
Conservation Achievement award: Wildlife Forever
Award of Excellence: Michael Allen, Ken Bovee and Randy Schultz
Hall of Excellence: Fred Harris
Distinguished Service award: Fred Janssen

GENETICS SECTION
James E. Wright Award: Matthew Krampe and Michael Sovic
Stevan Phelps Memorial Award: Kenneth P. Currens, Carl B. Schreck, and Hiran W. Li

MARINE FISHERIES SECTION
Steven Berkeley Marine Conservation Fellowship: Kristina Cammen
Honorable Mention: Justin Perrault and Hollie Putnam
Oscar E. Sette award: Michael H. Prager

INTERNATIONAL FISHERIES SECTION
2010 Carl L. Sullivan Endowment Fund Travel Grant:
Jade Sainz-Garduno (Marine Science and Limnology Institute, National Autonomous University of Mexico City (UNAM), Mexico
Carla Ibanez Luna from the University Mayor de San Andres in the Limnology Department, Cota Cota, Peru
Paulo dos Santos Pompeu, Fish Ecology Lab, Universidade Federal de Lavras, Brazil
Carlos Bernardo Mascarehas Alves, Universidad Federal de Minas Gerais, Belo Horizonte, Brazil
American Fisheries / Fisheries Society of the British Isles Membership Exchange Travel Award:
Ana Lewis (University of Southampton National Oceanography Centre, Southampton, UK)
Marybeth Brey (North Carolina State University, Department of Zoology, North Carolina, US)

PHYSIOLOGY SECTION
Award of Excellence: Steve F. Perry, University of Ottawa

9th International Congress on the Biology of Fish, 5-9 July 2010;
Best student oral presentation:
Erika Eliason
2nd: Tammy Rodela; 3rd: Christina Sørensen
Best student poster:
Yusuke Ito
2nd: Carlos F. C. Lanes; 3rd: Eduardo Fuentes Jofré

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Fisheries History Section: Randi Sue Smith
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Fisheries Law Section: Vacant
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Northwest Marine Technology, Inc.

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Arizona Game and Fish Department
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Atlantic States Marine Fisheries Commission
Bureau of Land Management
Colorado Division of Wildlife
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Delaware Division of Fish and Wildlife
Department of Marine Resources
Florida Fish and Wildlife Conservation Commission
Georgia Department of Natural Resources, Wildlife Resources Division
Grand River Dam Authority
Great Lakes Fishery Commission
Hawaii Department of Land and Natural Resources
Idaho Fish and Game Department
Illinois Department of Natural Resources
Indiana Department of Natural Resources, Division FWS
Iowa Department of Natural Resources
Kansas Department of Wildlife and Parks
Kentucky Department of Fish and Wildlife Resources
Louisiana Department of Wildlife and Fisheries
Maine Department of Inland Fish and Wildlife
Maryland Department of Natural Resources Fisheries
Massachusetts Division of Marine Fisheries
Michigan Department of Natural Resources
Minnesota Department of Natural Resources
Mississippi Department of Marine Resources
Mississippi Department of Wildlife, Fish and Parks
Missouri Department of Conservation
Montana Department of Fish, Wildlife and Parks
Nebraska Game and Parks Commission
New Jersey Department of Environmental Protection
New Mexico Game and Fish, Department of Fish Management
North Carolina Wildlife Resources Commission
Ohio Department of Natural Resources
Oregon Department of Fish and Wildlife
Pennsylvania Fish and Boat Commission
Rhode Island Division of Fish and Wildlife
South Dakota Game, Fish and Parks
Tennessee Valley Authority
Tennessee Wildlife Resource Agency
Texas Parks and Wildlife Department
U.S. Department of Agriculture, Forest Service
U.S. Department of Agriculture, Animal and Plant Health Inspection Service
U.S. Fish and Wildlife Service
Utah Department of Natural Resources, Division of Wildlife Resources
Vermont Department of Fish and Wildlife
Virginia Department of Game and Inland Fish
Washington Department of Fish and Wildlife
West Virginia Department of Natural Resources
Wisconsin Department of Natural Resources
Wyoming Game and Fish Department

SUSTAINING MEMBERS
Abernathy Fish Technology Center
Advanced Technical Aquatic Control LLC
Advanced Telemetry Systems Inc.
AIS Inc.
Alaskan Observers Inc.
Alpha Mach Inc.
Amirix Systems, Inc (VEMCO)
Arizona Cooperative Fish and Wildlife Research Unit
Armstrong-KETA Inc
BioSonics
Colorado State University
Columbia River Inter-Tribal Fish Commission
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of Warm Springs Reservation
Consolidated Safety Services, Inc.
Douglas Island Pink and Chum
FISHBIO
Fishways Global, LLC
Floy Tag and Manufacturing Co.
Forestry Suppliers Inc.
Gomez and Sullivan Engineers PC
Gulf of Maine Research Institute
Hallprint Pty Ltd.
Halltech Aquatic Research Inc.
HDR Engineering Inc.
Hubbs-SeaWorld Research Institute
Hydroacoustic Technology, Inc.
IAP World Services
Illinois Natural History Survey
Intake Screens, Inc.
Karuk Tribe of California
Kodiak Regional Aquaculture Assoc.
Kootenai Tribe of Idaho
Little Traverse Bay Bands of Odawa Indians
LOLIGO SYSTEMS
Marel
Miller Net Company, Inc.
Mississippi Alabama Sea Grant
Mora Fish Technology Center
New England Fishery Management Council
NOAA, National Marine Fisheries Service
Normandeau Associates Inc.
Northeast Consortium
Northern Southeast Regional Aquaculture Association
Ocean Associates, Inc.
Ohio State University
Ohio State University, Aquatic Ecology Lab
Ohio State University, Hatfield Marine Science Center
Okanagan Nation Alliance
Oregon RFID
Oregon State University
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Pentec Environmental
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Yurok Tribal Fisheries Program

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US Forest Service
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U.S. Fish and Wildlife Service, Fisheries Program SE Region
U.S. Fish and Wildlife Service, SW Region
Wisconsin Department of Natural Resources

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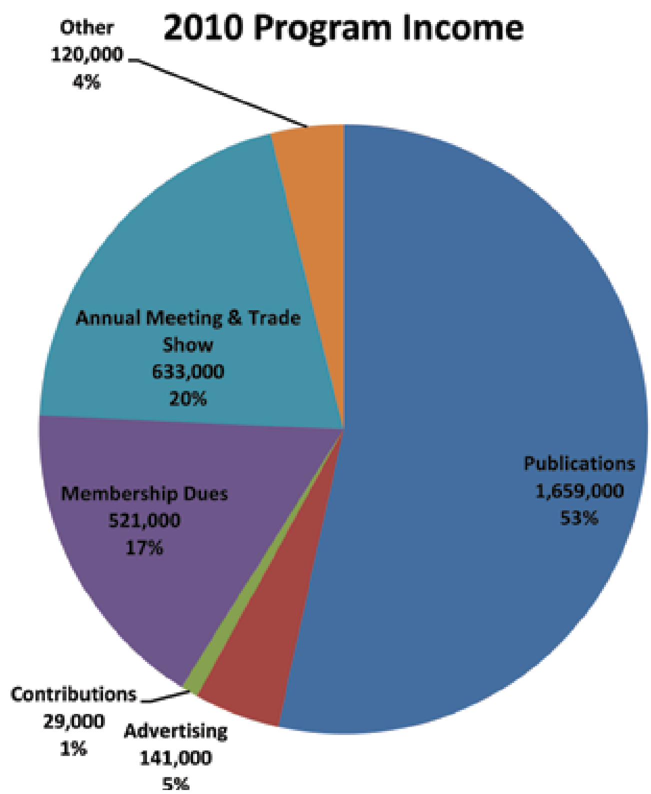
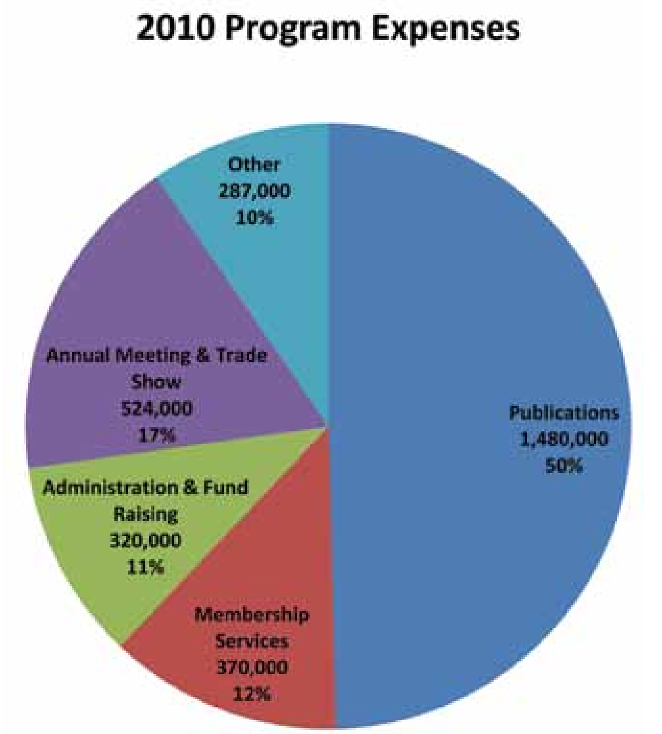
ORGANIZATIONS
America's Charities
United Way of CA Capital Region

American Fisheries Society 2010 Financials (Unaudited)

REVENUE		
Description	**Amount**	**%**
Publications	1,659,000	53.46
Advertising	141,000	4.54
Contributions	29,000	0.93
Membership Dues	521,000	16.79
Annual Meeting & Trade Show	633,000	20.40
Other	120,000	3.87
TOTAL	3,103,000	100
EXPENSES		
Description	**Amount**	**%**
Publications	1,480,000	49.65
Membership Services	370,000	12.41
Administration & Fund Raising	320,000	10.73
Annual Meeting & Trade Show	524,000	17.58
Other	287,000	9.63
TOTAL	2,981,000	100
CHANGE IN NET ASSETS	122,000	
Net assets at the beginning of the year	3,764,378	
Net assets at the end of the year	3,866,378	

ASSETS	
Cash	2,652,685
Investments	141,137
Accounts Receivable	2,084,589
Prepaid Expenses	10,985
Property and Equipment	550,703
Inventory	294,687
TOTAL	5,734,786
LIABILITIES	
Accounts Payable	473,139
Deferred Revenue	1,375,269
New Assets	3,886,378
TOTAL	5,734,786





SUNDAY, SEPTEMBER 4

6 p.m. – 10 p.m.
Welcome Social, Sheraton Seattle Ballroom

MONDAY, SEPTEMBER 5

8 a.m – 12 noon
Plenary Session, featuring:
Randall Peterman, Simon Fraser University
Billy Frank, Jr., Northwest Indian Fisheries Commission
Robert Lackey, Oregon State University
Jesse Trushenski, Southern Illinois University

11:30 a.m. – 8:30 p.m
Trade Show open

Registration for Annual AFS 5K Spawning Run closes.
Registration cost: $25.

TUESDAY, SEPTEMBER 6

9 a.m. – 5 p.m.
Poster Sessions open for viewing

5:30 p.m. – 7:30 p.m.
Student Career Fair and Social, Seattle Aquarium

WEDNESDAY, SEPTEMBER 7

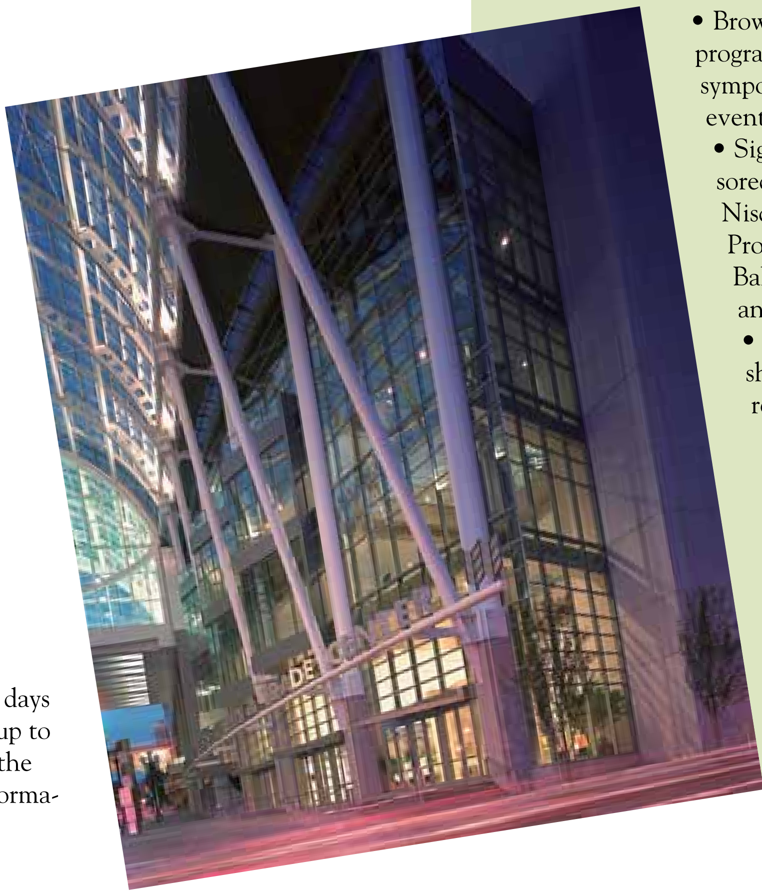
6 a.m. – 9 a.m.
Annual AFS 5K Spawning Run, starting at Alki Beach.

9 a.m. – 5 p.m
Poster Sessions open for viewing

9 a.m. – 2 p.m.
Trade Show open

5:30 p.m. – 11:30 p.m.
Grand "Space Needle" Social

This is only a small sampling of events! Please check **www.afs2011.org** in the days and weeks leading up to the conference for the most up to date information!



Set your sights on attending this year's Annual Meeting of the American Fisheries Society in beautiful Seattle, Washington, September 4–8, 2011.

With its focus on "New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World," the conference will provide a wonderful opportunity for fisheries professionals to meet, exchange information, catch up with friends, and find inspiration.

This year's meeting will be held at the Washington State Convention Center, located just a few blocks from the Seattle waterfront, with shops, restaurants, art galleries, and the Pike Place Market.

If you haven't done so yet, please visit the official conference website to register and book your room at one of the conference hotels, which are providing discounted rates for attending AFS members.

www.afs2011.org

At the website you can also:

- Browse the complete conference program, including courses, workshops, symposia, poster sessions, and special events
- Sign up for one of the AFS sponsored tours to locations such as the Nisqually River Estuary Restoration Project and Wildlife Refuge, or the Baker River Hydro Fish Passage and Propagation Facilities
- Get information on the trade show, student activities, childcare resources, and more

Support AFS and indulge yourself by coming to Seattle this September. We guarantee your experience will be a memorable one.

New AFS Members

Susan Benda
Sharon Benjamin
Russell Black
Charlotte Bodinier
Valerie Burd
David Caldwell
Sarah Collins
Emily Davis
Andy Davison
Katelyn Dowling
Chelsea Downing
Todd Duval
Steve Dwyer
Dennis Enyidi
Rachel Feeney
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Matthew Horsley
Tommie Huffman
Mark Hulsman
Jodee Hunt
Michelle Jakaitis
Ami Kidder
Ned Kirstein
Tomofumi Kurobe
Lauren Ledesma
Peter Levi
Evan Lindsay
Rachel Little
Rachel LovellFord
Dave Maraldo
Alexandria Marquardt
Hugo Marques
David Martin
Morag McPherson
Brent Mefford
Daniel Michrowski
Jean-Sebastian Moore
Robbie Mueller
Munmun Mukherjee
Vivian Nguyen
Bill Oeming
James Quadrino
Tess-Simone Ramirez
Stephen Reichley
Craig Roberts
Roberto Saad
Michelle Scanlan
Erik Schwab
Elizabeth Seagroves
William Shiels
Joyce Sisson
Amanda Smith
Andy Solcz
Michael Steiger
Jeffrey Stewart
Nate Taylor
Melissa Tracy
Matthew Waldrip
Morgan Wealti
Janis Webb
Andy Whitcomb
Casey Williams
Melanie Zölck

Congratulations to the Hutton Junior Fisheries Biology Program Class of 2011!

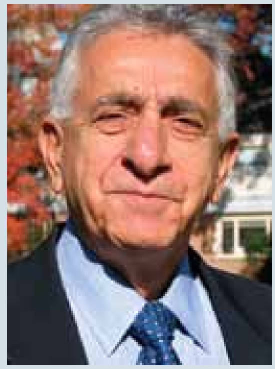
Hutton Scholars	Location	Hutton Mentors	Host Organization
Mariana Breña	Amherst, MA	Francis Juanes, David Stormer	UMASS Amherst
Jasmine Childress	Muncie, IN	Thomas Lauer, Mark Pyron	Ball State University
Antone Davis	New Braunfels, TX	Lee Gudgell, Debbie Magin	Guadalupe-Blanco RA
Jose Gonzales	Commerce City, CO	Scott Gilmore	CO Division of Wildlife
Candy González	Denver, CO	Scott Gilmore	CO Division of Wildlife
Ryan Johnston	Hampden, ME	John Kocik	NOAA NMFS
Cheng Li	Shoreline, WA	Janice Mathisen	Seattle Aquarium
Maggie McGowan-Stinski	Morley, MI	Jim Cline	USDA Forest Service
Darick Melvin	Flagstaff, AZ	Scott Rogers	AZ Game and Fish Dept.
Zachary Miller	Saratoga, WY	Shawn Anderson	USDA Forest Service
Erika Mincarelli	Palm Harbor, FL	Chris Barry, John Farrell	SUNY-ESF, TIBS
James Parente	Branford, CT	Jose Pereira	NOAA Fisheries Service
Alexandria Rhoads	West Haven, CT	Jose Pereira	NOAA Fisheries Service
Carlos Rodriguez	San Diego, CA	Heidi Dewar	NOAA
Hannah Russell	Flagstaff, AZ	Chuck Benedict, Matt Rinker	AZ Game and Fish Dept.
Sue-Jean Sung	Holmdel, NJ	Chris Chambers	NOAA Fisheries Service
Shyanne Winters	Dayville, OR	Dan Driscoll	Prairie Springs Fish Farm
Andrea Wong	Bellevue, WA	Eric Larson, Julian Olden	University of Washington

Mentor and Student Applications for the 2012 Hutton Program will be available online in October.
For more information about the Hutton Program, please visit the AFS website: www.fisheries.org, or contact Kathryn Winkler at 301-897-8616 ext. 213 or via e-mail: hutton@fisheries.org.

Column: DIRECTOR'S LINE

The Role of U.S. Federal Fisheries Staff in Professional Societies—Part II

Gus Rassam



AFS Executive Director Rassam can be contacted at grassam@fisheries.org

Note: In the April 2011 issue, this column (titled in error "The Role *in* U.S. Federal Fisheries Staff and Professional Societies") noted with approval a memo from John Holdren, science advisor to President Obama, emphasizing full participation of federal scientists in the total spectrum of professional society activities, whether attending meetings, publishing in peer-reviewed journals, or serving as officers or on governing boards of such societies.

As a result, many talented and capable federal scientists with obvious leadership qualities hesitated before accepting nomination for positions on the governing boards of professional society.

That memorandum, however, laudable as it was, did not mean necessarily immediate action. For years, the American Fisheries Society (AFS) and like-minded organizations (such as those now affiliated in the Coalition of Natural Resources Societies) have been working assiduously with relevant federal agencies to ensure full participation of federal employees in society business. Countless meetings and memoranda were exchanged. Everyone involved agreed with the wisdom of such participation. In reality, however, the relevant laws and regulations were left largely to the individual interpretation of the individual agency and administrator. No overall, explicit policy was articulated.

As a result, many talented and capable federal scientists with obvious leadership qualities hesitated before accepting nomination for positions on the governing boards of professional society.

Now, it seems, the Feds are moving in the right direction. The Federal Register of May 3, 2011, included a notice of Proposed Rules by the Office of Government Ethics on "Government Employees Serving in Official Capacity in Nonprofit Organizations" (Federal Register, Vol. 76, No. 85; 5 CFR Part 2640). Under these proposals, a rule amendment would permit government employees to participate in particular matters affecting the financial interests of nonprofit organizations in which they serve in an official capacity.

As background to this proposed amendment, the Register explains that until 1996, title 18 of the U.S. Code was interpreted by various agencies to mean that serving on boards of organizations such as AFS was not deemed in conflict with the duties and responsibilities of federal scientists. However, in 1996 the Department of Justice issued an opinion concluding that the federal code prohibits an employee from serving, in an official capacity, as an officer or director of a private nonprofit organization.

The proposed amendment reverses that interpretation and, it is to be hoped, permanently so. After comments are received to this proposal and the amendment is adopted, a major obstacle for full participation by federal scientists and managers in the affairs of their professional societies would be removed. This will redound positively for both the societies and the scientists.

Continued from page 369

and they did an outstanding job.

Andy Loftus took on the chair of the Electronic Services Advisory Board this year. We depend on this board for guidance on website development and other electronic services provided by AFS or needed to conduct its business, and they carried through on these duties quite well.

The External Affairs Committee chaired by **Walt Duffy** had many responsibilities involving communications to people outside of the Society, including the administration of the student writing contest and the public outreach award and assisting in the development of a briefing for members of congress and their staff. I commend the committee for a job well done.

The Membership Concerns Committee chaired by **Maureen Walsh** monitors the attitudes of members on various issues. This year they tackled the determination of attitudes of both certified and uncertified AFS members regarding the Professional Certification Program and provided valuable insight that will hopefully enhance the program.

This year's Nominating Committee was headed by **Tom Kwak**. The committee worked through the arduous process of identifying nominees for AFS second vice president and provided two outstanding candidates for the position.

The Society recognizes outstanding research contributions to fisheries science by identifying the best papers in four of our journals. This effort was conducted by the Publications Awards Committee under the leadership of **Bill Seaman** and diligent efforts of four subcommittees chaired by **Victoria Poage** (*Transactions of the American Fisheries Society*), **Jim Breck** (*North American Journal of Fisheries Management*), **Jim Steeby** (*North American Journal of Aquaculture*), and **Michael Mauel** (*Journal of Aquatic Animal Health*).

Derek Aday took on the task of chair of the Publications Overview Committee (POC) this year. This standing committee is composed of 11 people with the responsibility of providing oversight of AFS publications and review practices. This year the POC was charged with making recommendations for procedures for the appointment of editors and associate editors, developing recommendations for training of new editors and associate editors, and monitoring the transition to Taylor & Francis as publishers of AFS journals. They carried through in exceptional fashion.

The Resource Policy Committee (RPC) was chaired by **Tom Bigford**. The primary task of the RPC is to help evaluate, develop, and update AFS policy statements. This committee of 10 or more people addresses numerous policy issues and has several policy statements at various stages of development or revision. Success was felt this year with the passage of the Climate Change Policy Statement by AFS membership.

Several additional standing committees provided outstanding service to the Society, including the Audit Committee (**Craig Busacker** and **Mary Buckman**, cochairs), Awards Committee (**John Boreman**, chair, and several subcommittee chairs—**Christine Moffitt**, **Bill Fisher**, **Bob Curry**, **Mark Porath**, **Don Jackson**, and **Larry Alade**), Board of Appeals (**Barry Smith**, chair), Endangered Species Committee (**Noel Burkhead**, chair), Ethics and Professional Conduct Committee (**Mike Barnes**, chair), Investment Committee (**Henry Booke**, chair), Meeting Oversight Committee (**Chris Guy**, chair), Membership Committee (**John Boreman** and **Bob Hughes**, cochairs), Names of Fishes Committee (**Larry Page**, chair), Resolutions Committee (**Dennis Riecke**, chair), and Time and Place Committee (**Julie Claussen**, chair). All of the committees worked hard to carry out their assignments and did them well.

In addition to standing committees, the president creates special committees to address tasks not within the purview of standing committees. Several special committees functioned during the year. The Executive Director Succession Planning Committee chaired by our First Vice President, **John Boreman**, focused on process for transition in the future. A special committee chaired by **Peter Fricke** addressed comments on our draft policy on lead in sport fishing tackle and made excellent suggestions for revisions. The Hutton Junior Fisheries Biology Program continued to recruit and provide summer experiences for high school students under the direction of committee chair, **Cindy Williams**, and AFS staff member, **Kathryn Winkler**.

I cannot fail to recognize the extreme efforts by our Executive Director, **Gus Rassam**, and his staff in Bethesda, Maryland. Throughout the year I have had the opportunity to work with the folks in the home office and have been extremely impressed with their dedication. I thank Gus and all of the staff for their support and jobs well done.

Finally, I thank all of you for the opportunity to serve you as president. This unbelievable experience has been the capstone of my career. The AFS has provided innumerable opportunities for professional growth and development, publication of research findings, and networking for my students and me. I hope that I have been able to give a little something back to the Society. My very best wishes go to all members of AFS and, particularly, those who serve in leadership roles. Just keep this in mind, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 1949)—an extremely profound assertion and a principle to be maintained when leading the way in a changing world.

REFERENCES

Diamond, J. 2005. Collapse. How societies choose to fail or succeed. Penguin Books, New York.

Leopold, A. 1949. A Sand County almanac and sketches here and there. Oxford University Press, New York.

Calendar:
FISHERIES EVENTS

To submit upcoming events for inclusion on the AFS web site calendar, send event name, dates, city, state/province, web address, and contact information to sgilbertfox@fisheries.org.

(If space is available, events will also be printed in *Fisheries* magazine.)

More events listed at www.fisheries.org

DATE	EVENT	LOCATION	WEBSITE
Sep 4–8, 2011	AFS American Fisheries Society 141st Annual Meeting	Seattle, Washington	http://www.afs2011.org
Sep 19-23, 2011	ICES Annual Science Conference 2011	Gdańsk Music and Congress Centre, Gdańsk, Poland	http://www.ices.dk/iceswork/asc/2011/index.asp
Sep 22–24, 2011	Icelandic Fisheries Exhibition 2011	Smarinn, Kopavogur, Iceland	ttp://www.icefish.is
Oct 4-6, 2011	CONXEMAR - XIII International Exhibition	Vigo, Spain	http://www.conxemar.com/ingles/feria.htm
Oct 18-20, 2011	IFM Institute of Fisheries Management 2011 42nd Conference	Oxford, UK	http://www.ifm.org.uk/events/
Oct 26-27, 2011	The Lakes Ecosystem Conference (SOLEC)	Erie, Pennsylvania	http://ec.gc.ca
Oct 30-31, 2011	NPAFC International Workshop on Explanations for the High Abundance of Pink and Chum Salmon and Future Trends	Nanaimo, British Columbia, Canada	http://www.npafc.org/new/index.html
Nov 5-10, 2011	The Wildlife Society 18th Annual Conference	Waikoloa, Hawaii	http: www.wildlifesociety.org
Nov 14-18, 2011	Annual Alaska Chapter Conference	Girdwood, Alaska	htpp://www.fisheriessociety.org/afs-ak/
Dec 4-7, 2011	72nd Midwest Fish and Wildlife Conference	Des Moines, Iowa	http://www.midwest2011.org
Dec 6-8, 2011	62nd Northwest Fish Culture Conference 2011	Victoria, BC	www.gofishbc.com/nwfcc_2011.htm

August 2011:
JOBS

Employers: to list a job opening on the AFS online job center submit a position description, job title, agency/company, city, state, responsibilities, qualifications, salary, closing date, and contact information (maximum 150 words) to jobs@fisheries.org. Online job announcements will be billed at $350 for 150 word increments. Please send billing information. Listings are free (150 words or less) for organizations with associate, official, and sustaining memberships, and for individual members, who are faculty members, hiring graduate assistants. if space is available, jobs may also be printed in *Fisheries* magazine, free of additional charge.

Natural Resource Specialist II | Ecology and Fisheries, Ocean Associates, Inc. | California (various locations) | Temporary

Salary: $21.53/hr. Excellent employee benefits are provided including medical insurance, and holiday, vacation and sick leave.

Closing: Until filled

Responsibilities: Ocean Associates, Inc. has funded vacancies available for four Natural Resource Specialist II positions requiring education and experience in habitat ecology and fisheries to support NOAA National Marine Fisheries Service NMFS in Long Beach, Sacramento, Santa Rosa, and Arcata, CA (one position at each). The contract is for 12 months, beginning September 15, 2011 and ending September 12, 2012. Such contracts are often continued but this cannot be promised. Responsibilities include: Review and evaluate proposed projects and applications submitted to NMFS pursuant to sections 7 and 10 of the ESA. Evaluate and analyze effects of proposed actions, conservation measures, and mitigation activities on ESA-listed salmon, steelhead, green sturgeon, eulachon, black abalone and their habitat. Additional responsibilities can be found in the job description on our website.

Qualifications: Minimum experience or background requirements include a Bachelor Degree in fisheries, biological sciences, or natural resource management and 3 years of experience, or a Masters degree and one year of experience. Additional qualifications can be found in the job description on our website: www.oceanassoc.com/jobs/joblist.html

Web Link: www.oceanassoc.com/jobs/joblist.html

Contact Email address: Jobs@OceanAssoc.com

Manager, Fish Processing Plant | Columbia River Inter-Tribal Fish Commission | OR | Permanent

Salary: TBD DOQ

Closing: Until Filled

Responsibilities: Manager will be the CEO and responsible for all start-up and ongoing operations and business of this tribal-owned fish processing plant. Initially will be the only employee.

Qualifications: Experience managing start up operations of similar facility at least five years fish processing and marketing experience working knowledge of fiscal control, capital acquisition, business planning strong leadership and project management. Tribal hiring preference. See full details at below link.

Web link: www.critfc.org/fishco

M.S. in Stream Ecosystem Health | Univ of Arkansas Pine Bluff | student

Salary: Year 1: $17,800; Year 2: $18,800

Responsibilities: The graduate student will work with faculty and other students to conduct: Field investigation of nutrients, sediments, and other water quality parameters in streams; Watershed assessment; Stream biological macroinvertebrates and fish monitoring and data analysis with statistical tools.

Qualifications: B.S. in aquatic ecology, zoology, fisheries/aquaculture, biology, environmental sciences or related field. GPA of 3.0 and GRE score above 1,000.

Web Link: Bwww.uaex.edu/aqfi/people/faculty/ychen/

Contact Email address: ychen@uaex.edu

Post-Doctoral Research Associate | OK | Cooperative Fish and Wildlife Research Unit | phd

Salary: $49,000 plus benefits

Responsibilities: We are seeking a highly motivated postdoc to develop quantitative models useful in predicting the spawning success of Arkansas River shiner. Successful applicant will work with scientists at Oklahoma State University, Texas Tech University, and state and federal agencies to evaluate abiotic factors influencing transport of Arkansas River shiner eggs using field and laboratory techniques. Project is scheduled to begin June 2011 pending funding approval. Project end date is September 30, 2012.

Qualifications: PhD in fisheries, quantitative ecology, or related field. Strong GIS, spatial analysis, and predictive model building skills will be necessary for this project. Excellent written and oral communication skills are a must. A basic understanding of stream geomorphology would be helpful.

Contact: Send cover letter and CV with three references to: Dr. Shannon Brewer Oklahoma Cooperative Fish and Wildlife Research Unit OK State University Stillwater, OK 74078 or 405-744-9841.

Contact: Send cover letter and CV with three references to: Dr. Shannon Brewer Oklahoma Cooperative Fish and Wildlife Research Unit OK State University Stillwater, OK 74078 or 405-744-9841.

Contact Email Address: shannon.brewer@okstate.edu

Fish Pheromone Biologist | U of Minnisota at St. Paul | permanent

Salary: $40,000 - 45,000 with full benefits, renewable

Responsibilities: We seek a motivated biologist/chemical ecologist to develop an understanding of sex pheromones and other chemical cues used by Asian carp so that they can be used as tools to control this invasive species. Research will use a combination of behavior, ecology, and physiology in both the field and laboratory. It will be conducted at the University of Minnesota St. Paul in conjunction with government agencies. The successful applicant is expected to publish their findings. Starting date: Summer-fall 2011

Qualifications: M.S. in a field of biology. Ph.D. preferred. Excellent communication and leadership skills, demonstrated knowledge of fish behavior, field and laboratory experience, strong analytical skills, and the ability to work and publish independently.

Contact: Send cover letter, c.v., contacts for 3 references to Dr. Peter Sorensen at the email address below.

Contact Email address: soren003@umn.edu

Senior Scientist/Program Manager | MD | permanent

Salary: Negotiable and commensurate with experience and qualifications.

Responsibilities: Provide consulting support in fisheries, impacts of power generation and transmission facilities, environmental impact assessments, NEPA and resource management and policy development. Conduct business development activities within area of technical expertise, lead and contribute to proposal preparation, and participate in corporate marketing activities, with goal of $0.5 to $1.0M annually in contract funding individually or as a contributor.

Qualifications: Ph.D. or equivalent in marine science, fisheries, or quantitative ecology. Ten to 15 years experience in a consulting environment, at least 5 to 10 years experience in project management, and proven success in business development. Extensive experience with fisheries assessments, fisheries management, and impact of power generation facilities on fish populations desired comparable power industry experience in related ecological fields will be considered. Experience in application of ecological sciences in environmental impact assessments, knowledge of applicable state and federal environmental regulations, and outstanding writing and oral presentation skills required.

Contact: Apply on-line at below link, position number 2011-1263. You may also visit www.versar.com, and go to the About Us tab to access the Careers page for online application. Applications will be accepted until the position is filled

Web Link: https://jobs-versar.icims.com/jobs/1263/job

M.S. or Ph.D. Assistantship | Wildlife and Fisheries Resources Program | WV Univ | student

Salary: $15,450 M.S. or $18,540 Ph.D. annual stipend, plus full tuition waiver

Responsibilities: Successful applicants will participate in collaborative research projects related to the conservation genetics of fish populations and assist in laboratory classes such as Introduction to Fish and Wildlife Management, Fish Management, and other classes as assigned. Starting date is negotiable either 8/16/2011 (Fall start) or 1/9/2012 (Spring start).

Qualifications: Seeking highly motivated students with interests in fish conservation research. Requires a B.S. or M.S. in fisheries management, fisheries science, biology, genetics, or related field. Application prerequisites include a minimum undergraduate GPA of 3.0 and a minimum combined V Q GRE score of 1,000. Ad closing dates 7/15/2011 for Fall 2011 start, 11/16/2011 for Spring 2012 start.

Contact: Interested applicants should submit a letter of interest, resume, contact information for three references, and copies of transcripts and GRE scores via email. For additional questions on the positions contact: Dr. Amy Welsh, Wildlife and Fisheries Resources Program, West Virginia University, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506-6125, or at email below.

Web Link: www.forestry.caf.wvu.edu/students/graduates

Contact Email Address: amybwelsh@yahoo.com

Assistant Professor Marine Biology | Univ of West Florida | phd

Salary: Commensurate with experience.

Responsibilities: Position in Marine Biology. The Department of Biology at the University of West Florida, a comprehensive/ regional institution, invites applications for a 9-month, tenure-track position at the Assistant Professor level starting 1/1/2012. Applicants must have a Ph.D. in an appropriate field. Post-doctoral experience is preferred. Responsibilities include the standard teaching load at the undergraduate and graduate levels including, for example, Marine Vertebrate Zoology, Ichthyology, and General Zoology, serving on graduate committees and directing theses. Applicants are expected to establish an active research program that involves graduate and undergraduate students and that is supported by external funding.

Qualifications: Applicants are to apply online at below link the website of Human Resources at the University of West Florida. Be prepared to attach your curriculum vitae, letter of application/ interest, statement of teaching philosophy, statement of research interests/plans, and a list of three professional references. The applicant should also arrange for three letters of professional reference to be sent to: Marine Biology Search Committee, Department of Biology, University of West Florida, 11000 University Parkway, Pensacola, FL 32514. Full review of applications will begin September 2, 2011, but applications will be accepted until the position is filled. This position requires a criminal background screening. UWF is an Equal Opportunity/Access/Affirmative Action Employer. Pursuant to the Americans with Disabilities Act, any person requiring special accommodations to respond is requested to advise UWF by contacting the UWF ADA Office at 850 473-7469 voice or 850-857-6114 TTY.

Contact: Apply online at below link. For more information, please contact the Search Committee Chair, Dr. Wayne Bennett, wbennett@uwf.edu or Dr. Christopher Pomory, cpomory@uwf.edu at 850-474-2014, or the Department Chair, Dr. George Stewart at 850-473-7226.

Web Link: https://jobs.uwf.edu

Contact Email Address: wbennett@uwf.edu (Bennett); cpomory@uwf.edu (Pomory)

North Pacific Groundfish Observer | Alaskan Observers, Inc., | Bering Sea | permanent

Salary: $3,900.00–$6,340.00 per month, depending on experience, plus room, board, and travel to and from job site.

Responsibilities: As an at-sea biologist working aboard U.S.-flagged commercial fishing vessels, you will gather data essential to the sustainability of fisheries resources in Alaska. Observers sample catches to determine their species composition, make estimates of total catch, and collect age structures and biological data from target species. Observers are guaranteed subsequent deployment opportunities and salary advances. Positions available year-round

Qualifications: Minimum of a Bachelors Degree in fisheries biology, marine biology, general biology, zoology, or a related natural science.

Contact: Rachel Moore, at below link or 888-317-9343.

Web Link: www.alaskanobservers.com

Contact Email Address: r-moore@alaskanobservers.com

Graduate Research Assistant MS | Texas Tech Univ | student

Salary: $16,000 plus benefits and tuition waiver for 18 months.

Responsibilities: We are seeking a highly motivated graduate student to evaluate the effects of various environmental factors on Arkansas River shiner egg buoyancy and hatch rate. Successful applicant will work collaboratively with scientists at Oklahoma State University, state, and federal agencies. Project is scheduled to begin June 2011 pending funding approval. Project end date is September 30, 2012.

Qualifications: BS in fisheries, biology, ecology, or related field with a minimum GPA of 3.0 and GRE score of 1000.

Contact: Send cover letter and CV or resume with contact information for three references to: Dr. Tim Grabowski Texas Cooperative Fish and Wildlife Research Unit Texas Tech University Lubbock, Texas 79409 or 806-742-2851

Contact Email Address: t.grabowski@ttu.edu

Sr Fisheries Biologist/Aquatic Scientist | Gomez and Sullivan Engineers, P.C. | NY | permanent

Salary: Commensurate with experience

Responsibilities: Describe life history requirements and habitat needs for freshwater and diadromous fish. Interact and coordinate with client, professionals from other resource disciplines and coordinate with subconsultants.
Analyze and interpret study results to develop defensible conclusions. Prepare written scientific reports and other visual presentations of study results. Use your knowledge and skills to determine actual and potential impacts of various resource uses on fisheries and aquatic life. Interact with agency and non-governmental organizations on study planning and reporting Manage and participate in field efforts to collect scientific data.

Qualifications: Ten years experience in the design of aquatic resources studies and analysis of the results, as well as specific experience with the design and analysis of radiotelemetry, hydroacoustic, and PIT tag studies. Experience with FERC processes, effectiveness evaluation of fish passage facilities at hydroelectric projects as well as statistical analysis of fisheries data is a plus. Must have excellent verbal and written communication skills.

Web Link: www.gomezandsullivan.com

Environmental Specialist, MD | Environmental Service, MD | permanent

Salary: $32,000-$39,000.

Responsibilities: Assisting the DNR Fisheries Service with anadromous fish restoration projects, working at the Manning state fish hatchery in Brandywine, MD. Positions services may include, but are not limited to, directing field sampling projects, performing GIS analysis, assisting in the development and maintenance of a program-wide database, and supervising lower level technicians and biologists. Work may include field sampling, data collection, sample preparation, data entry, data analysis, sample analysis, and report writing.

Qualifications: BS in Environmental Science or related field, plus one year of related experience.

Contact: Send resume, Attn: 300580, to MES, 259 Najoles Rd. Millersville, MD 21108, or fax: 410-729-8235, or below e-mail. EOE.

Contact Email address: resumes@menv.com

Post-Doctoral Research Associate | Living Marine Resources Cooperative Science Center | permanent

Salary: $45,000

Responsibilities: Successful applicant will work with LMRCSC Director and Distinguished Research Scientist to develop program in quantitative fisheries, assisting the Director/Distinguished Research Scientist with directed research programs commensurate with his/her expertise, and instruction of graduate and undergraduate courses. Performs other related duties as assigned.

Qualifications: Ph.D. in Marine Sciences/Fisheries as related to population dynamics. Candidates should have strong quantitative skills and course work in fish biology/ecology and statistics as applied to fisheries. Experience in fisheries population dynamics including modeling, statistical methods used in evaluating fisheries data from field or laboratory research, fish biology and ecology and field research methods in fisheries, survey methods in evaluating individuals participating in recreational/commercial fisheries, and survey methods used in determining catch per unit effort and applications to fishery management.

Web Link: cfm?ID=Article&ArticleID=64637

Post-Masters Researcher | Pacific Northwest National Laboratory | WA | permanent

Salary: Starting $35,600, plus benefits. Possible relocation allowance.

Responsibilities: Assist with research using acoustic and radio telemetry to determine behavior and survival of salmonids. Assist with laboratory investigations on the influence of surgically implanting transmitters into fish. Responsibilities include field and lab work handling fish, conducting in-depth necropsies, maintaining fish populations and aquaculture facilities, data processing and analysis, field deployment of telemetry gear and assisting with surgical implantation of transmitters in fish.

Qualifications: Masters degree in biology or a fisheries related field. Knowledge of fish physiology, anatomy, aquaculture and telemetry techniques are desirable. Experience handling fish, surgical implantation of transmitters, managing data MS Excel and writing desirable. The ability to work well in a team setting is necessary.

Contact: Please visit below link and reference job posting 300817

Link: www.jobs.pnl.gov

Fisheries Biologist II | IAP World Services | FL | permanent

Salary: TBD

Responsibilities: IAP World Services is seeking individuals for Fisheries Biologist II positions at our NOAA/National Marine Fisheries Services Lab in Panama City, FL. Responsibilities include collection of field data, operation of small boats, processing gonads, sexing, maturation-staging on microscope, histology blocking processing otoliths, collecting, mounting, sectioning, assist other scientists to collect, process, and analyze biological samples, check for accuracy, assist with preparation of technical and research reports.

Qualifications: Minimum of a Masters degree in Marine Biology or related science or a BS degree and six years experience at the Fisheries Biologist I level. Computer literate, experienced with common word processing, database and graphics programs. Candidates must be a natural U.S. Citizen or a non-U.S. Citizen with at least 5 years of continuous residency in the U.S.

Contact Please apply through the IAP Website at under the careers link.

Web Link: www.iapws.com

Fisheries Policy Analyst | Environmental Defense Fund | permanent

Salary: TBD

Responsibilities: Location is Negotiable for the right candidate. Environmental Defense Fund is searching for a Fisheries Policy Specialist for our Oceans Program. Under the overall direction of the Gulf and Southeast Oceans Program Regional Director, and direct supervision of the Southeast Senior Conservation Manager, this position is responsible for implementation of area specific tactics, associated with strategies on commercial catch shares and other related commercial programs, which will bring these strategies to fruition. The Fisheries Policy Specialist will work with other Oceans team members to ensure the Gulf and Southeast Regions goals and objectives are met. Full-time, Permanent.

Qualifications: For full job description and application instructions please follow the link provided below.

Web Link: www.edf.org/page.cfm?tagid=371&jobID=655

Contact Email addresss: jobs@edf.org