VOL 33 NO 9
SEPTEMBER 2008

Fisheries

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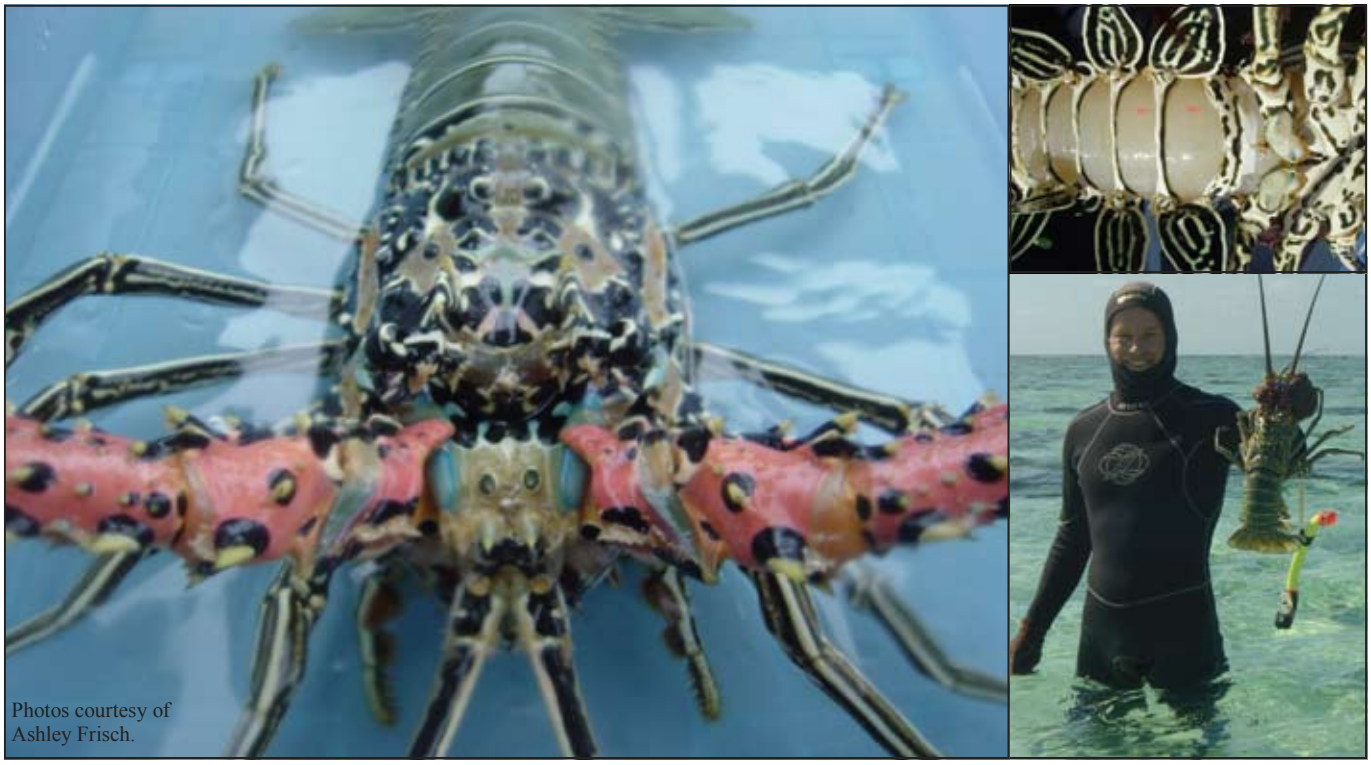
Development of New Water Temperature Criteria to Protect Colorado's Fisheries

Mapping the Changing Landscape of Fish-Related Journals:
Setting a Course for Successful Communication of Scientific Information

Discovering the Painted Crayfish



Photos courtesy of Ashley Frisch.

Painted crayfish *Panulirus versicolor* (above) are widely exploited throughout the coral reefs of the Indo-Pacific region, including Australia's Great Barrier Reef. They command a high price but relatively little is known about their biology and population dynamics.

Ashley Frisch, at James Cook University, (photo lower right) is beginning to unlock some of the painted crayfish's secrets. His studies first required a technique to identify individuals. Ashley tested NMT's injectable Visible Implant Elastomer tags and found them to be highly suitable[(1)] (photo top right). By using a combination of tag colors and locations, he devised a system for identifying up to 30,000 individuals.

Ashley's work now focuses on the population dynamics of the painted crayfish. He found that male crayfish live in coral reef dens. If the den is large enough for more than one crayfish, the male can attract females to share his den. Ashley's work also revealed that males with the largest dens can attract more than one female and increase their reproductive potential. Males with dens large enough to attract females must fastidiously defend them from other male crayfish, about one third of the population, that don't have dens large enough to share with a female. These "bachelor" males constantly roam the reef searching for a better den.

NMT is delighted to advise on projects and to help set up tagging programs, anywhere in the world. Please contact us if we can help with yours.

[(1)]Frisch, A.J. and J.A. Hobbs. 2006. Long-term retention of internal elastomer tags in a wild population of painted crayfish (*Panulirus versicolor* [Latreille]) on the Great Barrier Reef. J. Exp. Marine Biol. and Ecol. 339:104-110.

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The American Fisheries Society (AFS), founded in 1870, is the oldest and largest professional society representing fisheries scientists. The AFS promotes scientific research and enlightened management of aquatic resources for optimum use and enjoyment by the public. It also encourages comprehensive education of fisheries scientists and continuing on-the-job training.

Dues and fees for 2008 are $76 in North America ($88 elsewhere) for regular members, $19 in North America ($22 elsewhere) for student members, and $38 ($44) retired members. Fees include $19 for *Fisheries* subscription. Nonmember and library subscription rates are $106 ($127). Price per copy: $3.50 member; $6 nonmember. Fisheries (ISSN 0363-2415) is published monthly by the American Fisheries Society; 5410 Grosvenor Lane, Suite 110; Bethesda, MD 20814-2199

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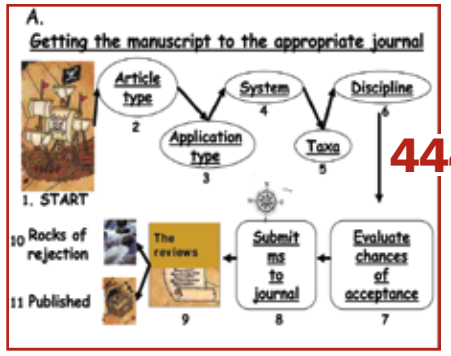

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ERRATA

Michael Cooperman's name was inadvertently omitted from the list of co-authors for the July article "Developing a Mechanistic Understanding of Fish Migrations by Linking Telemetry with Physiology, Behavior, Genomics, and Experimental Biology: An Interdisciplinary Case Study on Adult Fraser River Sockeye Salmon" (Fisheries 33[7]:321-338).

In the article "Conservation Status of Imperiled North American Freshwater and Diadromous Fishes" in the August issue (Fisheries 33[8]:372-407), the photo labeled as a female *Zoogoneticus quitzeoensis* on page 398 is actually a photo of *Hubbsina zaccapuensis* (also known as *H. turneri*), another species of Goodeid that is also included on the AFS list. Readers are encouraged to check the project website at http://fisc.er.usgs.gov/afs/ for future updates and corrections.

COVER: Brown trout (*Salmo trutta*), North Fork Cache la Poudre River, Colorado
CREDIT: schnitzerphoto.com

COLUMN: PRESIDENT'S HOOK

William G. Franzin
AFS President Franzin can be contacted at franzin@shaw.ca.

Plan of Work

What seemed like a distant dream back in September 2005, as I made the journey to the front of the room at the annual AFS Business Meeting in Anchorage, suddenly is reality. It has occurred to me each year as an officer, moving along that head table, that the opportunity to thank AFS members for your support comes only now, as your president. I am deeply honoured to serve you and the Society in this capacity. I know that in this year I will meet and get to know many more of you than ever before. I appreciate your confidence in electing me and meeting your expectations is my first priority.

In this, my first month in office, plans already are well underway for the 2009 meeting in Nashville. The first call for symposia and papers is in this issue. We have a great local arrangements committee working hard to provide an unparalleled experience in Nashville. I visited Nashville for the first time in May of this year. Let me tell you that the venue is superb and the Program Committee assures me that fisheries science will be the highlight of the meeting. 2009 is the official *Year of Science* (YOS) in the United States, celebrating the 200th birthday of President Abraham Lincoln, founder of the U.S. National Academy of Sciences. We plan to have a special session to commemorate YOS and highlight the importance of science to fisheries conservation and management.

The theme of the 2009 Annual Meeting and of my year as president is *Diversity, the Foundation of Fisheries and of AFS* followed by the question *Are we gaining ground?*

I want you to think of all aspects of diversity: the diversity of waters, of habitats, of faunas both fishy and not; the diversity of fisheries worked or enjoyed by millions around the world; and the diversity of people and disciplines that make up our Society. A high level of diversity in systems makes them resilient to external pressures, so it is essential that diversity be conserved and nurtured.

In my term of office I will re-examine the relationships of fisheries and the diversity of aquatic faunas.

Are we succeeding in halting the declines and restoring impaired fisheries and habitats?

Can we halt the continuing decline in biodiversity in marine and fresh waters?

Can we even reduce the rate of decline in biodiversity?

Can we eat our fish and have them too?

These are important questions that fisheries professionals have to consider.

If you have followed this September column over the last several years, you will notice that there is significant linkage between the annual programs of work. My time as an officer began when Barb Knuth was president. Her theme was "Creating a Fisheries Mosaic: Connections Across Jurisdictions, Disciplines and Cultures." Chris Kohler followed with "Fish in the Balance," with a focus on the need to find equilibrium between nature, as exemplified by fish, and humankind. Jennifer Nielsen brought forward "Looking Downstream and Downcurrent: Addressing Complexity and Unintended Consequences in Fish and Fisheries." Finally, this year, Mary Fabrizio focused on "Fisheries in Flux: How Do We Ensure Our Sustainable Future?" Working with this group of high fliers of course influenced me. The common thread in the themes of my predecessors and the one I have chosen for 2009 is that the physical and biological ecosystems that support fish are complex, have diverse faunas, and often respond to human interventions in unexpected ways, so it is essential that we maintain them into the future for our own well being. My theme, "Diversity as the Foundation of Fisheries and of AFS," returns our focus to the elements that comprise the complex fish faunas and the ecosystems that support them. I also recognize that we must nurture the diversity that is AFS, a complex inter-relationship of diverse professionals with a common purpose.

AFS is strong and vibrant because of the diversity of our professions, interests, capabilities, ethnicities, and demographics. We will remain strong through good governance, financial accountability, and strategic planning.

As we prepare our fourth strategic plan in 2009, I believe that we should determine if we have met objectives set in the previous plans. The strategic plans have been extremely useful to the Society for advancing our agenda, and for guiding and maximizing the efforts of both the parent Society and Units to return benefits to our members. We modify our strategic plans every five years to suit our needs in changing times. All of the strategic plans have included templates designed to facilitate measurement of the success of our efforts. However, we have not accomplished that for any of the strategic plans. I will strike an ad hoc committee to analyze those objectives and report on our achievements.

I look forward to serving you in 2008-09 and encourage everyone to communicate your needs and wishes to me. A more detailed Plan of Work with links to our Strategic Plan is on our website (www.fisheries.org/afs/aboutus_pow.html). ⚓

By JoAnne Castagna,
U.S. Army Corps of Engineers,
New York District

Students Soak Up Army Corps Workshops (with SpongeBob's help)

A young female school student from New York Public School 43 stands on the Rockaway Beach boardwalk and gently pokes a lifeless yellow mound lying on the bottom of a water tank, "What's this?" she asks.

"It's a yellow sea sponge—like the cartoon character, SpongeBob SquarePants, but unlike Bob this sponge doesn't have eyes, legs, arms, or a brain," explains Lisa Baron, a project manager with the Army Corps of Engineers Harbor Programs Branch.

The girl was stunned, as were her classmates surrounding her. It seems the students didn't make a connection between the popular cartoon character and the marine life that live in the waters right behind their school, which sits on Rockaway Beach, a peninsula on the south shore of Queens, New York.

This was the aim of the Rockaway Waterfront Alliance that asked the Corps to visit the students.

"The Corps' projects have protected the Rockaway shoreline and waterways for some time, but the local community and youth have never had the opportunity to find out how necessary this work is to keeping their waterways open," said Jeanne DuPont, director, Rockaway Waterfront Alliance.

A team of Corps biologists and engineers held several workshops for students at Rockaway Beach along the boardwalk right behind their school.

DREDGING WORKSHOP

Douglas Leite, project manager, New York District, U.S. Army Corps of Engineers, informed the students about the dredging work the Corps is performing off their shore and how it's beneficial to their community.

Over the years Rockaway Beach has eroded due to a number of reasons including severe storms over the years. To help replenish the shoreline, the Corps dredges the East Rockaway Inlet and places sand back onto the beach.

"We dredge sand from the East Rockaway Inlet and place it onto the beach to increase the size and reduce flood risk and coastal erosion, as well as provide a recreation area for the community," said Leite.

SEA LIFE WORKSHOP

Baron told the students that during dredging operations that the Corps does all it can to protect marine life in their natural habitat. The Corps uses deflectors to prevent sea turtles from getting caught in a dredge. Dredging work is done when species are not present.

Baron showed live species of Rockaway marine life for the students to hold and touch that included slime-covered moon snails, hermit and mole crabs, sea horses, mud snails, sea anemones, sea stars, and a yellow sea sponge. Baron said the students asked many questions and appeared very fascinated with the marine life.

"They were intrigued to learn that male sea horses play Mr. Mom and give birth to their babies and that sea stars regenerate their arms and pull their stomachs outside of their body to feed."

Some of the sea critters gave real life demonstrations for the students, such as a sea anemone that shot out its stinging cell at a baby sea star and attempted to eat it as students stared in amazement.

PIPING PLOVER WORKSHOP

Robert Smith, project biologist with the Corps' New York District, collected the critters from the East Rockaway Inlet. He talked to students along the beach about threatened and endangered species and how the Corps is taking measures to protect them.

One of these is the piping plover, a threatened shorebird due to beach erosion. Smith created a mock piping plover egg hunt for the students to show them what piping plover eggs and nests look like. During their hunt, he told the students that by the Corps building up the beaches with sand they are creating a habitat for the birds to nest and care for their young. He also said that the Corps schedules the sand placement outside the nesting season.

During Smith's workshop, a horseshoe crab slowly crept from the shore towards the students. Smith saw this as an opportunity to tell the students that horseshoe crabs are ancient creatures predating the dinosaurs—dating back over 500 million years.

The Corps' workshops created such a buzz among the students that their school's principal asked the Corps team to visit a class of second grade students.

Dupont said, "The Corps visit was extremely informative for the students. Their workshops also support the efforts that the Rockaway Waterfront Alliance has been addressing by encouraging public access to the waterfront though education with local youth."

Baron added, "To know that the Corps' outreach may inspire the students to become future scientists or merely improve their environmental awareness is rewarding." ⚓

FISHERIES CURRENTS:
SCIENCE NEWS FROM AFS

THIS ISSUE:
Award winning papers recently honored at the 138th AFS Annual Meeting in Ottawa in August

The Robert L. Kendall Best Paper Award in the *Transactions of the American Fisheries Society*

The ecological condition of a stream, river or lake can be measured with an index of biotic integrity (IBI) based on the fish and amphibian species found there. Knowing the tolerances of those species for human disturbance is key to developing an IBI. In the past, species tolerances were based on professional judgment, or were not available for many species (especially amphibians). In an award-winning paper in *Transactions of the American Fisheries Society,* scientists from Oregon State University, Dynamac Inc., and the U.S. Environmental Protection Agency have assigned tolerance values to 165 fish and 30 amphibian species found in western streams and rivers. An overall human disturbance measure was developed, using water quality, habitat, and watershed disturbance data from 1001 sites. Species abundances at those sites were used to produce species tolerance values, which were used to calibrate some of the IBI metrics. Species abundances and tolerance values were also used to calculate an assemblage tolerance index for the sites, as a measure of the condition of the aquatic community. **Fish and Amphibian Tolerance Values and an Assemblage Tolerance Index for Streams and Rivers in the Western USA,** by *Thomas R. Whittier, Robert M. Hughes, Gregg A. Lomnicky, and David V. Peck.* ***Transactions of the American Fisheries Society*** 136:254-271.

The Mercer Patriarche Best Paper Award in the *North American Journal of Fisheries Management*

More and more small, old dams across North American are being considered for removal both for safety reasons and to provide potential ecological benefits. Dams are thought to change fish communities by acting as barriers to fish migration, altering stream flows and temperatures, and creating reservoirs and tailwaters that foster different types of species. However, few studies have examined whether dam removal can bring back the diversity of species seen in undammed streams. Scientists from the U.S. Geological Survey and the Wisconsin Department of Natural Resources report on the effects of the removal of four dams on the Baraboo River in Wisconsin in an award-winning paper in the *North American Journal of Fisheries Management.* Capturing fish at 35 study sites over 7 years, they found many species not tolerant of conditions in dammed rivers had recolonized the Baraboo, and many fish species previously only found below the dams had spread upstream. **Effects of Dam Removal on Fish Assemblage Structure and Spatial Distributions in the Baraboo River, Wisconsin,** by *Matthew J. Catalano, Michael A. Bozek, and Thomas D. Pellett.* ***North American Journal of Fisheries Management*** 27:519-530.

The Best Paper Award in the *North American Journal of Aquaculture*

Managing hatchery ponds by nutrient manipulation is a delicate process of balancing nitrogen and phosphorus to produce the algae that feeds the zooplankton that in turn feeds the juvenile fish. The Texas Parks and Wildlife Department had a problem—toxic golden algae blooms in their hatchery ponds each spring and fall were killing off the bass and catfish fingerlings. Although the golden alga *Prymnesium parvum* could be controlled with copper sulfate or aluminum sulfate, these chemicals have harmful side effects like killing off the desirable algae or even the fish! In an award winning paper in the *North American Journal of Aquaculture,* the Texas researchers experimented with adding fertilizer to achieve nitrogen and phosphorus ratios that would allow the desirable green algae to outcompete the toxic algae, virtually eliminating *P. parvum* from their ponds in just two weeks. **Combined Nitrogen and Phosphorus Fertilization for Controlling the Toxigenic Alga *Prymnesium parvum,*** by *Gerald L. Kurten, Aaron Barkoh, Loraine T. Fries, and Drew C. Begley.* ***North American Journal of Aquaculture*** 69:214-222.

The Best Paper Award in the *Journal of Aquatic Animal Health*

Concern is growing about the increased detection of "dead zones" in coastal areas around the world. These dead zones have very low dissolved oxygen levels, also called hypoxia. Meanwhile, another cause of worry for fisheries biologists along the U.S. mid-Atlantic coast has been the outbreak of summer fish kills, many times with the fish exhibiting mysterious lesions. Is exposure to hypoxia causing immune system problems for fish? In an award-winning paper in the *Journal of Aquatic Animal Health,* researchers from North Carolina State University studied farmed Nile tilapia exposed to low but non-lethal levels of oxygen for five days. Using three tiers of increasingly specific blood and tissue sampling, the scientists found that acute hypoxia did compromise the immune system in test fish, suggesting that fish subjected to repeated bouts of hypoxia are more susceptible to disease outbreaks. **Acute Hypoxia-Reperfusion Triggers Immunocompromise in Nile Tilapia,** by *K. Choi, D.W. Lehmann, C. A. Harms, and J. M. Law.* ***Journal of Aquatic Animal Health*** 19:128-140. ⚓

JOURNAL HIGHLIGHTS: NORTH AMERICAN JOURNAL OF FISHERIES MANAGEMENT

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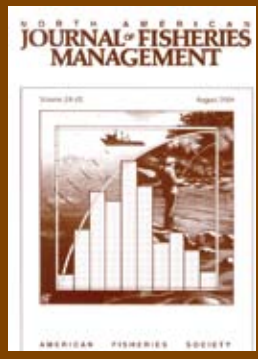
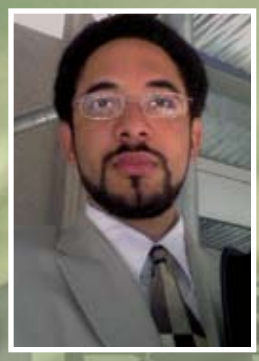


SPECIAL SECTION: STREAM RESTORATION

UPDATE: LEGISLATION AND POLICY

Elden Hawkes, Jr.

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



PROPOSED HIKE IN EASTERN BALTIC COD QUOTA

On 8 September 2008, the European Commission proposed raising quotas for eastern Baltic cod. The proposed hike in the quota stems from the general improvement of the Baltic cod stocks. Given the general improvement, the commission has proposed an increase in next year's quota by 15%. This would raise the quota to 44,580 metric tons for 2009 compared to the 2008 quota of 38,765 metric tons. The decision comes one year after opposition by Poland over quota restrictions. The opposition stems from the commission's banning of Polish fisherman from netting more cod after finding that they had filled their quota early, which many fishermen defied. Poland was eventually found to have surpassed its quota and the excess is to be deducted from its annual quotas until 2011. The proposal also calls for cuts of 15% in the smaller western Baltic fishery where there have been concerns over stock levels. This would cut the quota from 19,221 metric tons to 16,337 metric tons, and would affect mostly Denmark and Sweden. Also proposed by the commission was a cutting of herring quotas in the western Baltic by 63% and by 6% in the central Baltic. A 15% cut in salmon quotas was also suggested for the Gulf of Finland.

NEW EUROPEAN STRATEGY FOR MARINE AND MARITIME RESEARCH

In September, the new European Strategy for Marine and Maritime Research was set forth by the European Commission. It is hoped enhance the conservation of the fragile marine environment while facilitating development of maritime activities such as shipping and fisheries. The strategy contains two plans of action.

The first plan of action is designed to bolster the links between the marine research community and the maritime research community. This will be achieved by promoting interdisciplinary research on cross-cutting issues, such as global warming and the exploitation of marine renewable energy resources. Also, this plan of action will emphasize the development of new infrastructures.

The second plan proposes that a forum made up of stakeholders will be established to set common research priorities and establish measures to implement the strategy. The commission will oversee the implementation of the strategy and provide support. The commission is expected to deliver its first implementation report on the strategy by 2012.

UN GUIDELINES FOR FRAGILE SEA FISH SPECIES

On 4 September 2008, the United Nations (UN) announced new international guidelines to limit the impact of fishing on fragile sea species, after two years of consultations with concerned countries. The UN Food and Agriculture Organization (FAO) stated that managing deep sea fisheries in high seas areas outside of countries' exclusive economic zones has always been difficult, because it requires multilateral solutions involving not only nations whose vessels are engaged in deep sea fisheries but other interested countries as well.

Ichiro Nomura, assistant director general of FAO's Department of Fisheries, stated that until now, there really hasn't been an international framework for tackling this issue. He further elaborated that these guidelines are a breakthrough in that they address both environmental and fisheries management concerns in an integrated manner.

The guidelines recommend measures that can be taken to identify and protect vulnerable ecosystems and provide guidance on the sustainable use of marine living resources in deep-sea areas. They also recommend that fishing nations assess the deep sea fishing being undertaken by their fleets to determine if any significant adverse impacts are involved, and if there are adverse impacts, the fishing activity should stop. The guidelines set out steps for improving information on the location and status of vulnerable marine ecosystems and deep sea fisheries.

KENYAN NATIONAL FISHERIES POLICY

In September 2008, the Kenyan government announced that it is set to launch a national fisheries policy and master plan to guide the fishing industry in the country. Facing the repercussions of unscrupulous traders who have fished beyond the internationally-allowed region, the Fisheries Development Ministry's operations will be streamlined to ensure that Kenya's fisheries recourses are cared for.

Fisheries Development Minister Paul Otwoma states that the fisheries sector has been neglected in the past, but will now be restructured into three separate directorates. He also stated that the Kenyan government intends to set up an aquaculture fund to help small-scale fish farmers. This comes as region's water resources are faced by overexploitation coupled with the threat of diminishing water sources.

According to conservative figures, Africa currently produces 7.3 million metric tons of fish annually with an export value of over US $2.7 billion. The experts now say this is still below the region's full production potential.

Continued on page 472

FEATURE:
WATER QUALITY

Andrew S. Todd,
Mark A. Coleman,
Aimee M. Konowal,
Melynda K. May,
Sarah Johnson,
Nicole K. M. Vieira, and
James F. Saunders

Development of New Water Temperature Criteria to Protect Colorado's Fisheries

ABSTRACT: Water temperature fundamentally influences aquatic diversity and ecosystem health. In Colorado, temperature water quality criteria were revised in January 2007 based on a rigorous evaluation of the thermal requirements of fish species resident in Colorado. This article presents an account of how this process was conducted, and details the resultant criteria. The purpose of developing these criteria was to protect coldwater and warmwater fishes, especially native species such as cutthroat trout (*Oncorhynchus clarki*), from thermal stress. As such, lethal temperatures and optimal temperature conditions were determined from a literature review for species of the state, and these data were compiled into the Colorado Temperature Database. Acute and chronic thermal thresholds were then calculated for individual fish species. Finally, assemblages of fish were grouped into thermal tiers and temperature criteria were developed based on biological criteria for each assemblage. A case study is presented detailing the integration of science and policy decisions that shaped the development of Colorado's coldwater temperature criteria. Some issues were not resolved during this revision of Colorado's temperature water quality criteria, including protection from thermal shock and from gross changes in diel and seasonal thermal variability.

Desarrollo de nuevos criterios basados en la temperatura del agua para proteger las pesquerías de Colorado

RESUMEN: La temperatura del agua tiene una influencia innegable sobre la diversidad acuática y la salud del ecosistema. En enero de 2007, los criterios de calidad de la temperatura del agua en Colorado se revisaron sobre la base de una rigurosa evaluación de los requerimientos térmicos de las especies de peces residentes en el estado. En este artículo se presenta una relatoría de cómo se condujo este proceso y detalles de los criterios que se derivaron a partir de esto. El propósito de desarrollar estos criterios fue proteger del estrés térmico a los peces tanto de afinidad fría como cálida, especialmente especies nativas como la trucha degollada (*Oncorhynchus clarki*). Partiendo de una revisión bibliográfica sobre las especies presentes en el estado, se determinaron tanto las temperaturas óptimas como las condiciones térmicas letales; datos que fueron compilados en la Base de Datos de Temperatura de Colorado. Para cada especie se calcularon los límites térmicos críticos y crónicos. Finalmente se crearon asociaciones de peces de acuerdo a rangos térmicos y se desarrollaron criterios basados en la temperatura a partir de los criterios biológicos de cada asociación. Se presenta un caso de estudio de Colorado, detallando la integración entre la ciencia y la política de la toma de decisiones que ayudó a definir dichos criterios. En la presente revisión, no se resolvieron algunos aspectos sobre los criterios de la calidad térmica del agua en Colorado como la protección ante el estrés térmico y los cambios circadianos y estacionales de la temperatura.

Todd is a research biologist with the U.S. Geological Survey, Denver, Colorado, and he can be contacted at atodd@usgs.gov. Coleman is the principal scientist at Coleman Ecological, Inc., Fort Collins, Colorado. Konowal, May, and Saunders are water quality scientists at the Colorado Department of Public Health and Environmental, Water Quality Control Division, Denver. Vieira is a water quality researcher at the Colorado Division of Wildlife, Fort Collins. Johnson is manager of the Water Quality Standards Unit, Colorado Department of Public Health and Environment, Water Quality Control Division, Denver.

INTRODUCTION

Water temperature fundamentally influences aquatic diversity and ecosystem integrity, because the distribution, reproduction, fitness, and survival of aquatic organisms are inextricably linked to the thermal regime within a given environment. Elements within the temperature profile (e.g., maximum temperatures, daily and seasonal variability in temperature, the duration and frequency of extreme events) can provide important environmental cues that signal organisms when to grow, hibernate, or reproduce (Poole et al. 2004). As ectotherms, fish have evolved metabolic and reproductive requirements in response to natural temperature patterns; deviations from the natural thermal regime can have consequences for individual fish that can produce effects at the population and community levels. Myriad factors are known to govern water temperatures, including solar radiation/shading, surface air temperature, streamflow, hyporheic groundwater exchange, and channel or basin morphology. These factors can all be considered nat-

ural but they can also be heavily influenced by human activities, including agriculture and urban development. Additionally, anthropogenic point-source thermal discharges can directly impact aquatic thermal regimes, extensively altering the structure of aquatic communities (Caissie 2006).

Increasingly, regulators in western U.S. states must balance the consequences of expanding urbanization (e.g., reduced instream flows in basin of origin) with maintaining appropriate thermal regimes to preserve water quality and protect aquatic life. Regulators have responded by developing temperature criteria intended to protect recreationally, ecologically, or economically important fisheries. Temperature criteria in the western United States typically have focused on the protection of thermally-sensitive, coldwater obligate species. For example, temperature criteria in Oregon, Idaho, and Washington target thermal requirements for anadromous salmon and other threatened or endangered salmonid species, such as bull trout (*Salvelinus confluentus*) and Dolly Varden (*S. malma malma*) (USEPA 2003). In Colorado, a multifaceted strategy for regulating water temperature was required because temperature criteria are needed to protect aquatic communities across a broad spectrum of warmwater and coldwater aquatic habitats, many of which support threatened, endangered, or special status native fishes.

Temperature water quality criteria were first adopted by the Colorado Water Quality Control Commission in 1978, however, the lack of discernable scientific foundation and clear guidance for implementation prevented their application and the criteria were rarely enforced (CWQCC 2006). For this reason, with this criteria revision the commission sought to build on lessons learned from criteria development in other states to establish new science-based temperature criteria to preserve aquatic life. Many of the defining characteristics of Colorado's fisheries (e.g., the predominance of headwater mountain stream miles, the transition from coldwater to warmwater fish communities, and the presence of rare native fish species with special state or federal status) were considered to develop biologically meaningful temperature criteria implementable within the state's current regulatory framework. Through this process, the commission ultimately decided to incorporate a combination of quantitative metrics and narrative provisions into Colorado's temperature criteria to ensure comprehensive protection for resident fishes. Quantitative metrics were adopted to prevent thermal modifications of a magnitude, frequency, and duration deemed deleterious to fishes, including during critical reproductive seasons. Select narrative provisions were included where important thermal characteristics were not expressly protected with quantitative metrics, typically because of implementation concerns or as a result of scientific uncertainties. These new criteria were granted initial approval by the commission in early January 2007 and the USEPA in August 2007, effectively establishing new water temperature criteria for Colorado.

Water quality criteria development in Colorado is a collaborative process, engaging state, federal, non-profit, and industry groups. As such, the participation of stakeholders plays an important role in shaping proposals that are presented to the commission, which must weigh the evidence and reach conclusions that also address policy considerations. Herein, we describe the development of the Colorado water temperature criteria based on our involvement in technical issues throughout the process. These new temperature criteria represent a significant improvement over the criteria that had been in place for decades, but still should be viewed as part of an iterative process. We provide a detailed account of how the new coldwater temperature criteria will be applied in Colorado, and also identify issues that warrant further consideration, perhaps leading to additional revisions.

FISH THERMAL REQUIREMENTS

To develop criteria to protect fish from acute and chronic deleterious temperature exposures, we compiled data on thermal requirements and tolerance limits for fish species resident in Colorado into the Colorado Temperature Database (CTD) (CWQCD 2006). A technical advisory committee consisting of fisheries biologists and water quality specialists from academia, state and federal regulatory agencies, environmental consulting firms, and industry groups developed a list of factors and recommended criteria to establish a methodology for screening potential data (Table 1). Once these screening criteria were adopted (CWQCC 2006), temperature data from the scientific literature were reviewed for inclusion into the CTD. This effort was necessarily extensive (504 papers were reviewed), as data were sought on the unique thermal preferences and tolerance limits of each fish species in Colorado. Of the 504 papers reviewed, 346 were not included in the database because they failed to meet the screening criteria (Table 1). Most were eliminated because they were reviews or compilations of results from other studies and therefore did not present original study results. The CTD ultimately contained results from 158 studies providing acceptable thermal tolerance, optimum, or preference data for 8 of 10 coldwater and 43 of 63 warmwater fish species resident in Colorado (CWQCD 2006). When no data were available that met all desired qualities, or when there were additional factors in the experimental design that were not included among those in Table 1, the technical advi-

Table 1. Factors considered in judging quality of experimental data, to insure that the best available data were included for each species in the Colorado Temperature Database (CWQCC 2006).

Criteria	Description
Replications	Number of replications documented
Endpoint of the study	Intent to study thermal tolerance stated
	Clear biological endpoint stated
Acclimation history	Sufficient time allowed for acclimation of test organism
Acclimation rate	Acclimation rate reported
Life stage	Life stage of the test organism reported
Methods	Control group utilized and reported
	Adult- or juvenile-sized fish used
	Nutritional status well documented
	Standard testing environment used
Peer-reviewed study	Evidence of peer review presented
	Study present in a published scientific journal or referenceable report
	Data derived from original study
Quality of fish	Documented attempts to reduce stress on experimental fish
Fish source	Information on origin and history presented

sory committee was consulted to help determine whether the data should be included when calculating temperature criteria.

One defining factor in the development of the acute and chronic temperature criteria was the inclusion of solely laboratory-derived temperature tolerance data in the calculation of statewide water temperature criteria. While many field studies have yielded relevant thermal information such as field observations of thermal preferences and realized thermal niche, the inherent site-specificity and complexity of factors shaping relationships between stream conditions and thermal preferences render field data less reliable for the derivation of broadly applicable temperature criteria. For example, an organism's thermal limit in a given stream is influenced by countless variables, including both exacerbating factors (e.g., lack of forage or habitat, cumulative effects of other stressors) and mitigating factors (e.g., presence of thermal refugia). Further, results from laboratory studies have long formed the basis for water quality criteria, because laboratory settings facilitate controlled exposure and accurate assessment of biological response to the parameter of interest in isolation, albeit under simplified environmental conditions. As such, the CTD includes primarily laboratory-derived data, supplemented by results from field studies to facilitate ground-truthing of thermal limits derived from laboratory studies. For example, water temperature criteria developed through Colorado's approach were compared with thermal limits determined using field-based approaches (e.g., Eaton et al. 1995; Huff et al. 2005) to ensure that results were relatively consistent.

Results from two standard experimental approaches were used to define acute thermal thresholds: the critical thermal maximum (CTM) and upper incipient lethal temperature (UILT) methods. In the CTM technique, fish acclimated to a constant or fluctuating temperature regime are subjected to uniform rates of temperature change until loss of equilibrium, spasms, or death occurs (Hutchison 1979; McCullough 1999). In contrast, the UILT method usually involves an instantaneous transfer of fish acclimated to a given temperature regime to a higher fixed potentially lethal temperature (Fry et al. 1942). The UILT is then identified as the temperature at which 50% mortality occurs over a specified time interval (typically 1 to 7 days). In recent years, some researchers have modified the standard UILT procedure by raising temperatures at the maximum rate expected under natural conditions, rather than rapidly transferring fish to each lethal test temperature (e.g., Smith and Fausch 1997; Selong et al. 2001).

Importantly, both UILT and CTM metrics are positively correlated with acclimation temperature (i.e., the temperature at which fish are conditioned leading up to the test exposure), with higher acclimation temperatures generally producing higher thermal tolerances up to a point (Figure 1). The point at which the uppermost UILT is reached, and no longer increases with increasing acclimation temperature, is known as the ultimate upper incipient lethal temperature (UUILT). The UUILT is considered a final maximum temperature threshold; however, the UUILT is seldom determined and reported in the literature. To be comprehensive, both CTM and UILT data, complete with associated acclimation temperatures and other metadata pertinent to evaluate experimental design, were compiled in the CTD.

Chronic thermal thresholds were calculated using laboratory data on thermal preferenda, thermal optima for growth and other activities (e.g., swimming performance), and thermal tolerance zones. These chronic measures of fish thermal requirements also vary with acclimation temperature. As such, acclimation temperatures and other metadata related to experimental design were included in the CTD (CWQCD 2006). Upper thermal optimum data were deemed the most relevant threshold to use in setting biologically meaningful chronic temperature criteria. Thermal optima are determined through one of two experimental approaches. In growth optimum experiments, fish are fed ad libitum at various temperatures to identify the temperature that maximizes growth of experimental fish (Hokanson et al. 1977). In performance optimum experiments, swimming speed, endurance, or some other aspect of performance are tested at various temperatures to determine the temperature range required for optimum performance (Lee et al. 2003).

TEMPERATURE CRITERIA: GENERAL APPROACH

Acute Criteria

Acute temperature criteria are intended to protect fish from lethal exposures to very warm temperatures. In theory, the acute thermal criteria should represent the upper limit of thermal tolerance for a given fish species, minus an appropriate margin of safety. Based on input from the technical advisory committee, the UUILT for a fish species was selected by the commission to serve as the basis for acute water temperature criteria. Because UUILT exposures typically last for up to a week in length,

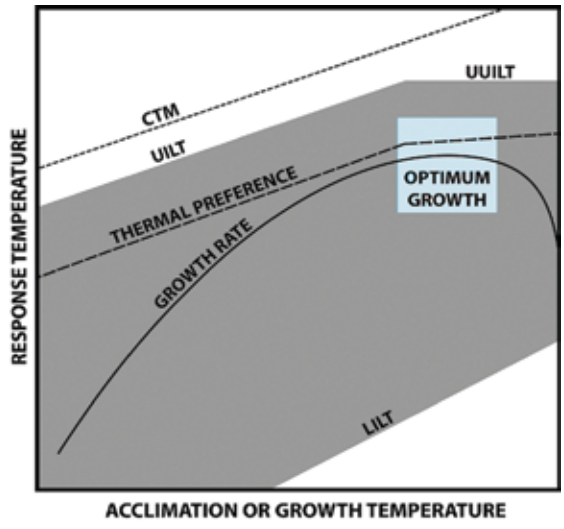


Figure 1. Conceptual thermal tolerance polygon and temperature-growth relationship for fishes. The gray area outlines the thermal tolerance polygon. The critical thermal maximum (CTM; ---) and thermal preference (- -) are also included, and like the lower and upper incipient lethal temperatures (LILT and UILT, respectively), are positively correlated with acclimation temperature. Acclimation temperature is the temperature at which fish are conditioned leading up to test exposures. The UUILT is the ultimate UILT, which marks the maximum UILT obtained, regardless of further increases in acclimation temperature (after Reynolds and Casterlin 1979). Growth rates (—) in fishes rise with temperature to an optimum range (light blue box) and then drop sharply at higher temperatures that approach lethal limits. Because of the relatively consistent relationships among upper thermal tolerances, preferences, and the temperature-growth relationship, thermal preference is sometimes used to estimate thermal tolerance and growth optimum temperatures.

versus CTM exposures which are typically of a much shorter duration, the committee determined that UUILT was the most conservative (and thus protective) metric for setting daily maximum temperature thresholds. When the UUILT was not available, UILT data at acclimation temperatures representing "summertime conditions" in Colorado streams were used to approximate the UUILT. When neither a UUILT nor an appropriate UILT was available for a species, CTM minus a conversion factor was used to approximate UILT. Given the differences in experimental approach, CTM has been observed to be several degrees higher than the reported UUILT for the same coldwater species (e.g., Lohr et al. 1996). As such, for some species (e.g., brown trout, *Salmo trutta*), species-specific conversion factors were developed to allow estimation of UILTs from CTM data. It was necessary to develop these conversion factors using data that were excluded from the CTD, due to the lack of UUILT and UILT data consistent with the screening criteria.

Once acute criteria were determined, a margin of safety was subtracted to adjust acute values to no-effect levels. This approach was consistent with existing U.S. Environmental Protection Agency (USEPA) water temperature guidance, which recommends that acute criteria for short-duration exposures be set at the 50% lethality level (e.g., UUILT), minus a margin of safety (USEPA 1986). Although the USEPA guidance suggests that 2°C below UUILT is an acceptable margin of safety, the source literature that the guidance cites (Black 1953) reveals that 2°C is an average of variable temperature spans identified between 50% and 0% lethality levels for many different warmwater and coldwater species. For this reason, a blanket margin of safety was not used as the default. Instead, species-specific margins of safety were developed using a 1/5th rule, where 1/5th of the difference between the UUILT and thermal optimum was subtracted from the UUILT. In this manner, the margin of safety was established as a consistent percentage of the relative thermal distance between species-specific upper thermal limits and thermal optima. For coldwater species with sufficient data (i.e., sockeye salmon *Oncorhynchus nerka* and brook *Salvelinus fontinalis*, brown, rainbow *O. mykiss*, and cutthroat trout *O. clarki*), the resultant mean calculated using the 1/5th rule was 1.92°C, with a range of 1.42°C (brook trout) to 2.68°C (brown trout). The commission adopted this novel approach for the default margin of safety except when there were no data available to calculate a species-specific value; in those cases a 2°C margin of safety was used.

Chronic Criteria

Chronic criteria are intended to protect resident aquatic life from sub-lethal exposures to warm temperatures sufficient to cause detrimental effects on long-term survival, growth, and reproduction. Therefore, chronic metrics should reflect detectable thresholds of key sub-lethal effects, such as decreased reproductive success, reduced consumption and growth, increased predation, or behavioral abnormalities. For species with a defensible upper thermal optimum in the literature, the commission set the chronic criteria as equal to the upper optimum temperature, with the intent that an upper optimum temperature reflects that threshold between optimal and detrimental chronic conditions.

Upper thermal optima were not available for most species; therefore, alternate approaches and surrogate data were used to calculate chronic temperature criteria for many species. When thermal optimum data were available but an upper optimum was not identified, the species-specific chronic temperature criterion was calculated as the optimum plus 1/3rd of the difference between the optimum and the lethal threshold (UUILT or estimated UUILT) for that species (the 1/3rd rule; USEPA 1986). The 1/3rd rule was originally intended to approximate "an average of the optimum temperature for growth and the temperature for zero net growth" (USEPA 1986), and in this case, was employed as the best-available surrogate of upper optimum temperature for a given species. When thermal optima and/or UILT data were not available, thermal preference data and CTM values (converted to approximate UUILT) were used as surrogates within the 1/3rd rule, respectively. Only those data with acclimation temperatures within the range of normal summertime water temperatures for Colorado's coldwater streams were used to calculate acute and chronic values.

Application of Temperature Criteria

Thermal criteria were developed for several groupings or "tiers" of coldwater fisheries in Colorado waters. Coldwater fish with similar thermal requirements were grouped into tiers for both lotic and lentic systems. Coldwater tiers include: (1) sensitive headwater fisheries and (2) "non-sensitive" lower-elevation brown and rainbow trout fisheries, including Gold Medal fisheries (minimum trout standing stock of 60 lbs. per acre and minimum average of 12 quality trout [>14 inches] per acre) featuring these species (see Table 2). Each tier also includes protection of thermal needs during critical reproductive periods for all fisheries by incorporating thermal criteria in winter that are considerably colder than the criteria for the summer months (Table 2).

Table 2. Water temperature criteria for coldwater Colorado fisheries (CWQCC 2007). Attainment of the acute criterion in rivers and streams will be evaluated through comparison with the daily maximum (DM) temperature, defined as the highest two-hour mean water temperature measured within a given 24-hour period. Attainment of the chronic criterion in rivers and streams will be evaluated through comparison with the MWAT, calculated as the seven-day mean of consecutive daily mean temperatures, where daily means are calculated from multiple, equally spaced values per day. Lakes and reservoirs will be evaluated through comparison of the chronic criterion with mixed layer mean temperatures from individual thermal profiles taken within the time period of July–September.

Category	Applicable dates	Criteria
Rivers and streams	June–September	17.0°C (chronic), 21.2°C (acute)
Rivers and streams (reproductive season)	October–May	9.0°C (chronic), 13.0°C (acute)
NS rivers and streams*	April–October	18.2°C (chronic), 23.8°C (acute)
NS rivers and streams (reproductive season)*	November–March	9.0°C (chronic), 13.0°C (acute)
Lakes and reservoirs	April–December	17.0°C (chronic), 21.2°C (acute)
Lakes and reservoirs (reproductive season)	January–March	9.0°C (chronic), 13.0°C (acute)
Large lakes and reservoirs**	April–December	18.2°C (chronic), 23.8°C (acute)
Large lakes and reservoirs (reproductive season)**	January–March	9.0°C (chronic), 13.0°C (acute)

* NS refers to non-sensitive streams, applied where cutthroat trout and brook trout are not expected to occur at the site.
** Large lakes and reservoir criteria are applied on lakes and reservoirs that are equal to or larger than 100 surface acres.

Criteria durations are expressed as the daily maximum (DM) temperature for the acute criterion and as the maximum weekly average temperature (MWAT) for the chronic criterion. Both acute and chronic criteria are values that are not to be exceeded more than once in three years. The DM is defined as the highest two-hour average water temperature measured within a given 24-hour period. The MWAT is calculated as the seven-day mean of consecutive daily mean temperatures, where daily means are calculated from multiple, equally spaced values per day. While the commission considered using the seven-day average of the daily maximum temperature as the chronic metric instead of the MWAT, they concluded that because acute protection would be provided by the DM, and because the MWAT considers all of the data in the diel cycle (not just the daily maxima), the MWAT would be the preferable chronic metric because it provides a true measure of chronic (as opposed to acute) exposure.

Assignment of default table value criteria (TVC) or the alternative non-sensitive species TVC in any given coldwater stream will occur via the rolling implementation of these standards through Colorado's annual individual river basin standards review process. As each basin is reviewed during this process, the appropriate coldwater criteria for each stream segment will be determined through the thorough consideration of "species expected to occur at the site." Because existing stream thermal classifications were assigned during the initial establishment of water quality criteria in Colorado, and were based on best professional judgement at that time, it is probable that select streams will need to be reclassified as coldwater or warmwater habitat based on evidence obtained during this rotating basin review process (consistent with the federal use attainability analysis requirement). Further, within the individual basin standards review process, stream-specific information (e.g., local forage limitation) or data regarding species expected at the site (e.g., through habitat limitation) can be utilized, where appropriate, to establish site-specific standards that are more or less stringent than default TVC.

DEVELOPING TEMPERATURE CRITERIA: COLD WATER EXAMPLE

Regulatory Rationale

In defining guidelines for deriving numerical water quality criteria for the protection of aquatic organisms and their uses, the USEPA asserts that "because aquatic ecosystems can tolerate some stress and occasional adverse effects, protection of all species at all times and places is not deemed necessary" and that "reasonable level of protection will likely be provided if all except a small fraction of the taxa are protected, unless a commercially, ecologically, or recreationally important species is very sensitive" and requires a more restrictive criterion (USEPA 1985). For many traditional toxics (e.g., zinc), the most common risk-based calculation is based on the protection of 95% of genera from lethal (acute) or sub-lethal (chronic) effects (USEPA 1985).

In order to be consistent with this USEPA risk-based guidance, database-derived acute and chronic thermal tolerance values for individual fish species were compiled. The species-specific acute and chronic values were ranked from most to least sensitive, and the 5th percentile value of each was calculated and used as the acute or chronic criteria for that tier. This approach differs from the traditional USEPA approach, in that individual species rather than genera were ranked. The limited number of fish species resident in Colorado and differences in thermal sensitivities within resident genera made the species approach more meaningful and protective. For Colorado's coldwater stream species, acute temperature criteria were set according to this approach, resulting in a default, acute criteria of 21.2°C (Table 2). Although the Arctic grayling (*Thymallus arcticus*) has an acute threshold lower than this value, the highly limited distribution of this species within Colorado prevented lowering the acute criteria to its threshold. However, chronic temperature criteria based on the 5th percentile approach did not fully protect the most sensitive species, the cutthroat trout (see Table 3). With three subspecies native to Colorado (greenback, Rio Grande, and Colorado River cutthroat trout), the cutthroat trout was deemed ecologically and recreationally important, and coldwater acute criteria were lowered to ensure its full protection. Through this regulatory adjustment, the thermal limits of the cutthroat trout were positioned to drive the TVC for all coldwater streams. As such, the commission was significantly concerned that the TVC might not be attainable in coldwater streams statewide. Therefore, in order to assess the statewide attainability of this policy decision, a comprehensive analysis of the thermal and biological characteristics of Colorado's coldwater streams was conducted.

Table 3. Acute and chronic water quality criteria for individual Colorado coldwater stream species, as calculated using the Colorado Temperature Database (CWQCD 2006). Margins of safety were subtracted from UILT data to obtain the acute value presented in this table.

Common name	Scientific name	Chronic (°C)	Acute (°C)	Margin of safety (°C)	Number of studies
Cutthroat trout*	*Oncorhynchus clarki*	17.0	22.1	1.96	7
Rainbow trout	*Oncorhynchus mykiss*	18.2	23.8	1.88	16
Brook trout	*Salvelinus fontinalis*	18.3**	21.7	1.42	12
Sockeye salmon	*Oncorhynchus nerka*	19.0**	22.9	1.67	2
Brown trout	*Salmo trutta*	19.6	24.6**	2.68	8
Arctic grayling	*Thymallus arcticus*	No data	21.0	2.00***	1
Longnose sucker	*Catastomus catastomus*	No data	24.9	2.00***	1
Mottled sculpin	*Cottus bairdi*	No data	No data	–	1
Lake trout	*Salvelinus namaycush*	No data	No data	–	3
Mountain whitefish	*Prosopium williamsoni*	No data	No data	–	1

* Data used in the derivation of cutthroat criteria include data from Bonneville, Lahontan, Snake River, Westslope, and Yellowstone sub-species
** Value calculated through the 1/3rd rule (chronic) or through CTM-UILT conversion (acute).
*** Default margin of safety.

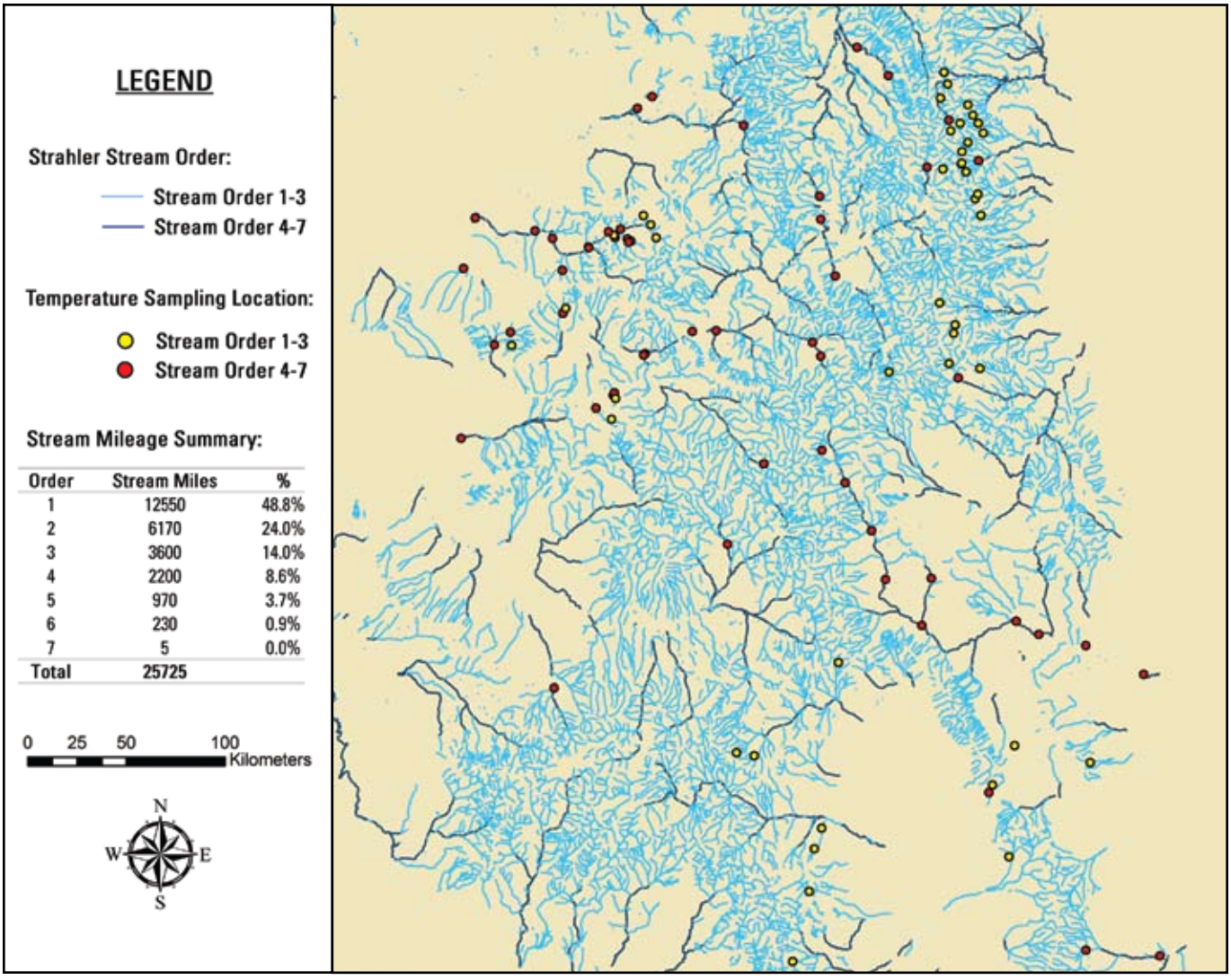
Attainability and Biological Community Analyses

Stream ordering is a widely applied method for classifying streams, and the Strahler (1952) method is very simple and commonly used by stream biologists. In short, progressively higher order streams drain progressively larger watersheds. The River Continuum Concept (Vannote et al. 1980) postulates that headwater streams (first through third order) behave differently from medium-sized streams (fourth through sixth order), noting that biological communities in headwaters are largely comprised of species that tolerate only a narrow range of temperatures. Cold water temperatures in headwater streams of mountainous regions are usually attributed to high watershed elevation and snowmelt-driven flows.

In order to determine the relative prevalence of coldwater streams of each order in Colorado, GIS analysis was conducted that considered several important data parameters, specifically Strahler stream order, stream length, and existing stream thermal classification (cold or warm; 100,000:1 map scale). Summing the lengths of stream miles from each stream order, it was determined that more than 85% of perennial stream miles presently classified by the commission as cold water in Colorado were first to third order, thus falling into the headwater category (Figure 2).

To field validate the statewide attainability of the implementation of default, laboratory-derived TVC within Colorado's coldwater streams, temperature records from various locations in coldwater streams were assembled (Figure 2). This spatially diverse data set included data from first- through sixth-order streams from a wide range of elevations. Importantly, degree of anthropogenic influence was not considered as a factor for inclusion/exclusion of thermal data, and many of the datasets used within this analysis originated from thermally-perturbed streams (particularly in higher-order streams). As such, this evaluation was used as a screening tool to estimate the attainability of lab-based temperature thresholds, when compared with observed field temperatures. Raw data within each data set included, at a minimum, daily maxima and minima for the several months spanning the hottest weeks of summer during recent years. Where data sets contained more than one year of data, the year with the highest observed temperatures was included in the comprehensive data set. A positive trend was

Figure 2. Colorado coldwater streams classified according to Strahler stream order with locations of temperature monitoring sites. Original GIS shapefiles obtained from the Colorado Division of Wildlife at http://ndis.nrel.colostate.edu/ftp/index.html.



observed between stream temperature and stream order, and the measured DM and MWAT within first- through third-order headwater streams typically fell below both default laboratory-derived coldwater temperature TVC (Table 2), regardless of stream elevation and location (Figure 3). As such, this evaluation indicated that coldwater TVC based on thermal thresholds for sensitive coldwater species were attainable for a large majority of coldwater stream miles in Colorado.

Additionally, data from fisheries surveys conducted by the Colorado Division of Wildlife were used to analyze salmonid distributions relative to stream order in Colorado. This analysis determined that brook trout and cutthroat trout typically inhabit cold headwater streams classified as first- through third-order, while brown and rainbow trout replace these species in higher order streams. In conjunction with the above attainability analysis, this fish species distribution analysis supported the application of the cutthroat-based criteria as the default coldwater TVC for temperature, given that the 85% of coldwater stream miles are headwater streams (first through third order), and that headwater streams are cutthroat trout habitat.

Reproductive protection

While the derivation of coldwater temperature criteria detailed above reflects a scientifically rigorous review of the acute and chronic thermal limits of adult fish, these criteria alone were determined to be insufficient to fully protect Colorado's coldwater fisheries. While these upper-limit temperature metrics provide thermal protection to aquatic ecosystems primarily during the hottest portions of the year, coldwater streams in Colorado typically exhibit seasonal temperature cycles, and metrics designed to be protective during one season may be under-protective in another. Trout have a host of life-cycle attributes that are specifically keyed to changes in stream temperature, including pre-spawning, spawning, embryo development and maturation, fry growth, and adult migration. As such, protection of seasonally-variable temperatures that meet all life-cycle thermal requirements are essential to maintain viable trout popula-

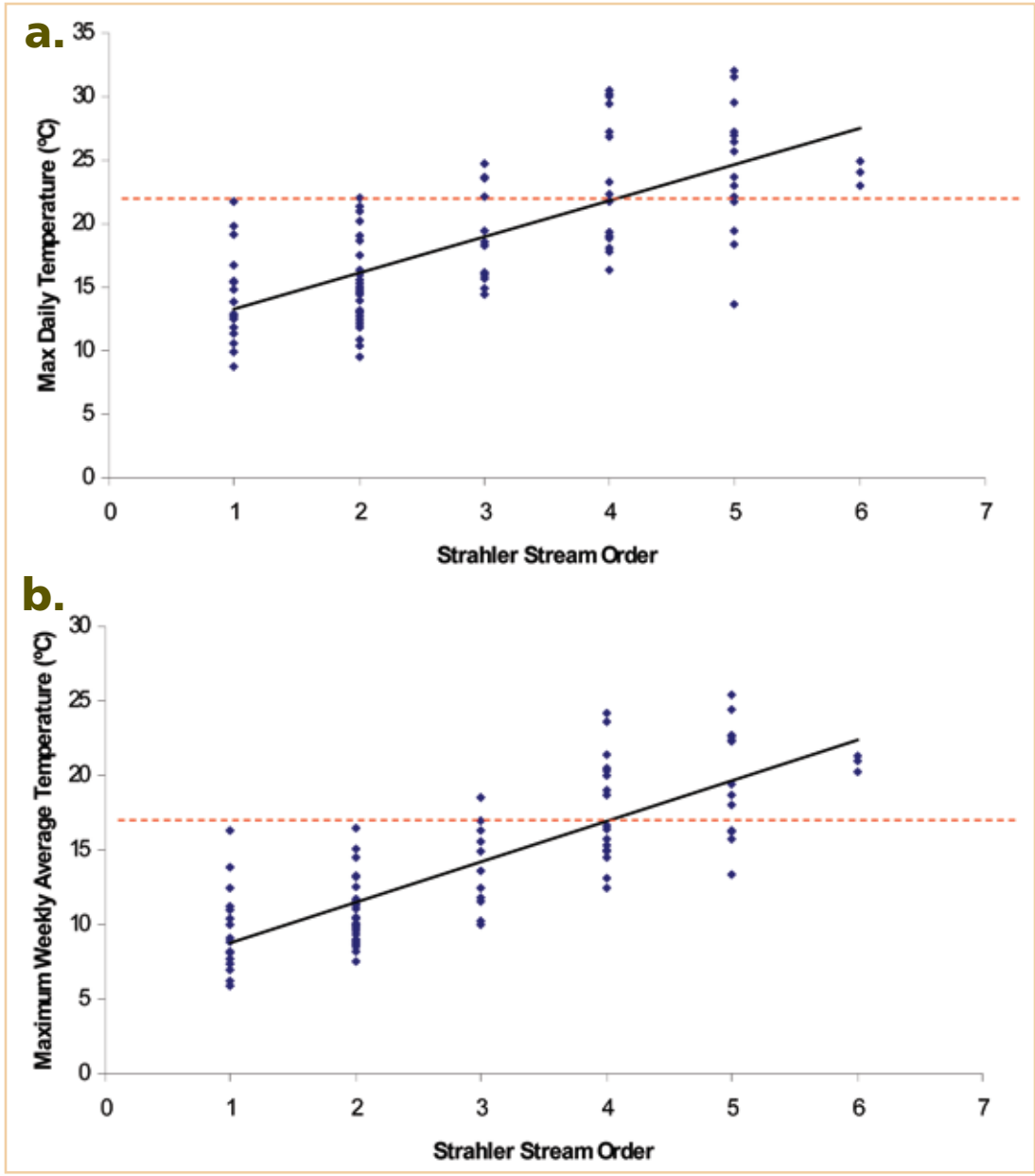


Figure 3. Relationships between Strahler stream order, field measurements of maximum daily temperature and maximum weekly average temperatures (MWAT) in Colorado's mountain ecoregions. Dashed lines represent cutthroat-trout-based acute (a.) and chronic (b.) table value criteria. Data sources include stream temperature data from the U.S. Geological Survey, Christine Hirsch (unpublished data, USDA Forest Service, White River National Forest, Glenwood Springs, Colorado), Chris Kennedy (unpublished data, U.S. Fish and Wildlife Service, Rocky Mountain National Park, Estes Park, Colorado), and stream temperature data summarized elsewhere in Harig and Fausch (2002), and Coleman and Fausch (2007).

tions. In fact, sensitivity to small deviations from the natural thermal regime may be highest during these critical periods of a fish's life cycle, including reproductive cycles during the winter (McCullough 1999).

Initially, the concept of an acceptable level of thermal deviation metric was proposed for the preservation of seasonal thermal variability, wherein a requirement would have been established to limit the deviation above or below the natural (or expected) thermal regime. The purpose would be to limit the degree of anthropogenic influence on seasonal thermal variability. Additional benefits to this approach were identified, including the preservation of daily temperature fluctuations and natural rates of temperature change. While this type of approach has been adopted by several western states, several pitfalls were identified related to the practicality and feasibility of implementation of such a metric. Specifically, concerns were raised regarding the inherently subjective/difficult nature of defining a "natural" thermal regime in a state with intensive water management, including cross-basin diversions, heavy water withdrawal, and over-allocated water rights. Furthermore, in basins with presently altered thermal regimes, significant cumulative impacts may already exist, and therefore, setting a cap on future thermal increases may not be protective of natural form and function. How to define and protect natural thermal regimes for aquatic ecosystems with highly manipulated flow regimes remains a challenging issue throughout the West.

As an alternate approach to protecting seasonal temperature variability, a second set of thermal criteria protective of sensitive critical reproductive cycles was defined. This alternate method presented several challenges, including the characterization of the thermal boundaries of a generic coldwater reproductive cycle, and the identification of a default reproductive season. Initially, USEPA guidance for fish reproductive temperatures was considered. Table 12 of the USEPA *Gold Book* presents a summary of reported values for spawning and short-term maxima for embryo survival during the spawning season (USEPA 1986). Only two of the species in this table, brook and rainbow trout, are coldwater species and resident to Colorado. The USEPA recommends a chronic criterion of 9°C and an acute criterion of 13°C for both species (USEPA 1986). Additional studies were identified that reported similar acute and chronic thermal limits for salmonid species, including brook trout (Hokanson et al. 1973; USFWS 1982), rainbow trout (Pankhurst et al. 1996; USFWS 1984), brown trout (USFWS 1986; Armstrong et al. 2003), and cutthroat trout (Fraley et al. 1981). Ultimately, these multiple additional lines of evidence served to substantiate *Gold Book* values as protective of the coldwater reproductive cycle in Colorado.

Inherently low species diversity and similar species-specific spawning preferences facilitated the development of a default spawning season for Colorado's coldwater streams. In simplistic terms, brown trout and brook trout are known as "fall spawners," whereas cutthroat trout and rainbow trout are typically deemed "spring spawners," although rainbow trout are known to occasionally spawn in the fall. Although this division is technically sound in that the physical act of spawning for each species typically occurs during the fall or spring, in the larger life-cycle context, many coldwater fish species have similar thermal life-cycle requirements across seasons. For example, while brown trout spawn in the fall, successfully fertilized eggs require cold temperatures to develop over the winter and hatch in the spring (Behnke 2002). Similarly, while cutthroat and rainbow trout usually spawn late in the spring, the eggs within gravid females are sensitive to elevated temperatures in pre-spawning months. Therefore, it is most appropriate to protect temperatures during a broad reproductive season, and not simply during the period of fish spawning.

One challenge in defining a generic spawning season for Colorado's trout species is that the dates at which water temperatures become suitable for spawning vary naturally, driven in part by factors such as elevation. In order to attempt to define an attainable, generic time frame for application of a default reproductive season temperature criterion, the same temperature database used in validating summer coldwater TVC was employed. In this case, study sites with year-long stream temperature records were targeted, and using the trout reproductive threshold values derived above (acute = 13°C; chronic = 9°C), months of the year in which all days fell below these threshold thermal limits were identified. The results of this analysis indicated that even in select higher order streams (fourth through sixth order), coldwater streams sustained temperatures significantly colder than the coldwater spawning criteria for a significant proportion of the year. In headwater stream reaches (first through third order), temperatures protective of trout reproduction were sustained for the period of October–May, which corresponds with known timing of spawning activities. This analysis illustrated that the period from October–May represents a scientifically defensible, default coldwater reproductive season, and so it was established as such within Colorado's coldwater TVC.

Transitioning to warm waters

As demonstrated above, coldwater TVC are biologically defensible and attainable for the overwhelming majority of streams classified as cold water in Colorado. However, rivers in Colorado generally become warmer with decreasing elevation, resulting in gradual changes to downstream thermal regimes. Colorado's temperature criteria needed to be flexible enough to acknowledge the spectrum of temperatures along longitudinal and elevation gradients. Colorado's new water temperature criteria explicitly allow for the consideration of alternate thermal thresholds where appropriate.

The CTD indicates that trout species inhabiting larger waters (typically brown and rainbow trout) have higher thermal tolerances than do headwater cutthroat and brook trout populations. In practice, the cutthroat trout-based TVC will be applied as default numeric criteria when making implementation decisions, unless scientifically substantiated evidence demonstrates that cutthroat trout or brook trout populations are not expected to occur at the site. In this case, a second tier of TVC (rivers and streams with biota that are "not sensitive"), based on thermal thresholds for rainbow trout, will be applied. This second tier of coldwater criteria is useful in maintaining brown and rainbow trout populations in Colorado's Gold Medal waters, where the combination of warmer temperatures and abundant food promotes outstanding growth rates. Finally, using a site-specific recalculation procedure, alternative thermal criteria could be developed in large coldwater rivers that could be scientifically demonstrated would not naturally support salmonid populations (e.g., habitat limitation). Through this recalculation pathway, large coldwater rivers would be afforded higher temperature thresholds that would be both scientifically defensible and protective of resident, non-trout fish communities (USEPA 1994; CWQCC 2006). In practice, the tiered approach and recalculation pathways are designed to allow for a gradual transitioning of coldwater temperature criteria as coldwater streams progress downstream into coolwater and warmwater fish assemblages.

WARMWATER CRITERIA

Although the primary focus of this article has been the development of coldwater temperature criteria in Colorado, as a part of the same process and through the same approach,

new criteria for Colorado's warmwater streams were developed and adopted. In several ways, criteria development was more challenging for warmwater streams. Given the number and diversity of warmwater species in Colorado, many of which lack primary literature on thermal preferences and limits, it proved difficult to populate the database with either preferred data (UILT and upper optimum) or surrogate data (CTM and thermal preference). Similarly, it was difficult to approximate preferred data from surrogate data (e.g., CTM-UILT conversion). Further, fundamental differences in the relative thermal ecologies of warmwater and coldwater fish made the use of common tools problematic. For example, in contrast to coldwater fish, the span between optimal and lethal temperatures in warmwater fish is often very narrow (e.g., Stauffer et al. 1984). As such, use of the 1/5th rule to calculate an acute margin of safety may result in numerically similar acute and chronic species-specific values, and questions about whether the similarity of the acute and chronic criteria is appropriate, or an artifact of deficiencies in the supporting data. Mindful of these challenges, acute and chronic criteria were developed for several tiers of warmwater fish with similar thermal requirements and conservation status, for both lotic and lentic systems Each tier also includes a cooler criterion for winter months. Resultant warmwater criteria are presented elsewhere (CWQCC 2007). In the future review of these warmwater criteria, the appropriateness of utilizing an identical approach in calculating coldwater and warmwater criteria will be revisited.

THE FUTURE OF COLORADO'S TEMPERATURE CRITERIA

While Colorado's new temperature criteria represent significant advancement from the previous state temperature criteria, several critical issues raised during their development remain unresolved. Although the CTD reflects a thorough and detailed review of available primary thermal literature, for many fish (particularly rare or native species) and species forming the forage base, the data are lacking, and the identification or generation of additional data to augment the CTD would make the criteria more robust. For example, to better reflect the intent of the commission, future criteria reviews will seek to replace chronic values calculated via the 1/3rd rule with experimentally-derived upper optima. In this manner, the database is an evolving entity, and new data that meet data screening guidelines can be incorporated into future criteria review. Further development of the CTD is an essential step in the refinement and evolution of Colorado's temperature criteria. Additionally, novel criteria approaches (e.g., 1/5th rule to establish the acute margin of safety) will be carefully scrutinized as additional experimental data become available that can be used to evaluate alternative approaches. Finally, with a more robust dataset, the future establishment of TVC for additional species assemblages (e.g., cool water or transitional fisheries) may be warranted.

Furthermore, although Colorado's new suite of acute and chronic metrics serves to establish seasonal ceilings on temperature, the development of additional metrics to better protect the thermal environment of resident fish warrants future consideration. Currently, several of these concerns are captured within a generic narrative criterion that states "temperature shall maintain a normal pattern of diel and seasonal fluctuations and spatial diversity with no abrupt changes and shall have no increase in temperature of a magnitude, rate, and duration deleterious to the resident aquatic life." Indeed, patterns of thermal fluctuation below maxima may be equally important in preserving the ecological integrity of streams and rivers. Streams in Colorado can exhibit fairly dramatic daily thermal cycles, with large temperature swings and the

warmest temperatures occurring for only a portion of the day. Recent scientific studies demonstrate that fish are better able to survive exposures to high daily temperatures if such exposures are cyclic, with intervening cool periods during which recovery can occur (Johnstone and Rahel 2003). As such, the development of metrics to ensure the maintenance of diel variability should be considered in future reviews of Colorado's temperature criteria.

Another critical issue that warrants consideration, currently addressed with narrative language, is the concept of thermal shock. Thermal shock is believed to result from abrupt changes in stream temperature caused by anthropogenic activities (both rapid warming and cooling), and can result in serious sub-lethal and lethal consequences for resident fish, including increased susceptibility to predation, increased avoidance energy costs, and other negative effects (Parker and Krenzel 1969; McCullough 1999). Unfortunately, to date, the scientific community has studied thermal shock to a lesser extent than it has lethality metrics, such as UILT and CTM. Specifically, few studies have been designed to quantify rates of temperature change that are harmful to aquatic biota when experienced repeatedly, as could be the case in a stream routinely influenced by anthropogenic thermal inputs. This lack of relevant scientific literature makes it difficult to develop "rate-of-change" thermal shock metrics. Recognizing both the potential importance of this parameter and anticipated confusion over its implementation, the commission has directed the Colorado Water Quality Control Division (staff to the commission) to continue to explore a practical means to protect aquatic life from anthropogenic thermal shock by the 2010 Basic Standards rulemaking proceedings.

SUMMARY

The newly adopted temperature criteria for Colorado, and the marriage of science and policy to arrive at these criteria, can serve as an example for other states seeking to develop biologically defensible, attainable coldwater thermal criteria. Although not covered extensively in this article, Colorado's new warmwater temperature criteria likely may assist with reviews of thermal criteria in states with native warmwater fisheries. It is our hope that this article inspires more research in the area of thermal tolerances, optima, and preferenda of native coldwater and warmwater fishes. Furthermore, it is clear that the scientific community needs a better understanding of the negative impacts of thermal shock, and the positive benefits to be gained by preserving thermal refugia that can be found in diel and seasonal temperature variability. ⚓

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FEATURE:
PROFESSIONAL ISSUES

Mapping the Changing Landscape of Fish-related Journals: Setting a Course for Successful Communication of Scientific Information

ABSTRACT: In the last 25 years, the number and scope of fish-related journals have changed. New and existing journals are increasingly specialized. Journals that are read and cited are changing because of differential accessibility via electronic databases. In this review, we examine shifts in numbers and foci of existing fish-related journals. We ask how these fish-related metrics differ across type of application, ecological system, taxa, and discipline. Although many journals overlap to some extent in content, there are distinct groups of journals for authors to consider. By systematically reviewing the focus of an individual manuscript, comparing it to the suite of journals available and examining the audience for the manuscript, we believe that authors can make informed decisions about which journals are most suitable for their work. Our goal here is to help authors find relevant journals and deliver scientific publications to the appropriate readership.

Mapeo de los cambios de ámbito de las revistas relacionadas a los peces: fijando el rumbo para una comunicación efectiva de la información científica

RESUMEN: En los últimos 25 años, el número y ámbito de las revistas científicas relacionadas a los peces ha cambiado. Tanto las revistas existentes como las nuevas se han especializado cada vez más. Aquellas revistas que son leídas y citadas también están cambiando a la luz del acceso diferencial a bases de datos vía electrónica. En esta revisión se examinan los cambios en número y foco de estudio de las revistas científicas existentes relativas a los peces. Se cuestionó cómo éstas medidas difieren entre tipos de aplicación, sistemas ecológicos, taxa y disciplinas. A pesar de que muchas revistas coinciden en cuanto a su contenido, forman grupos distintos para la consideración de los autores. Mediante una revisión sistemática del foco de estudio de un manuscrito particular, comparándolo con la gama de revistas disponibles y examinando su audiencia potencial, es posible que los autores tomen decisiones informadas acerca de qué revista es más apropiada para su trabajo. El objetivo de este estudio es ayudar a los autores a encontrar revistas relevantes y colocar las publicaciones científicas en la audiencia más pertinente.

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INTRODUCTION

Publication is a primary form of communication within the scientific process. A research project is not complete until it is published. Publishing scientific data and theory in an appropriate journal is the principal way science can be made available to relevant audiences. Reasons to publish may be motivated by a desire to extend scientific knowledge in general, facilitating more effective, sustainable, and equitable resource use, and the desire for professional advancement. Scientific communications can take many different forms. Reasons to publish can affect both the type of manuscript written and the outlet to which that manuscript is submitted.

To communicate effectively, authors must consider both their target message and audience. Distinct audiences, including scientists, managers, and policymakers, may have different goals (i.e., to advance science, make sound management decisions, or implement conservation oriented policy; Parrish et al. 1995). Consequently, different outlets and their audiences require diverse scientific foci, breadth of questions, and levels of technical knowledge. Specifically, the type of application (i.e., general, fisheries, management, conservation biology, or none), ecological system, taxa, and scientific discipline may be important in considering how and where particular manuscripts are published. Communicating to other scientists in the author's own technical field may require one manuscript format and outlet, while communicating to scientists who are experts in a broad array of disciplines may require another. Likewise, having an impact on scientists, managers, and policymakers who work on a specific applied issue may require yet another type of presentation and outlet. Consequently, determining which journals are the appropriate outlets for specific scientific communications can be a complex issue. Many authors choose journals based on their experience or professional memberships, which may or may not be appropriate. Because the publication landscape is continually changing, it is important to be strategic about where manuscripts are submitted.

The landscape of fish-related literature is dynamic. Although fisheries (McCain 1994) and marine biology (Fuseler-McDowell 1988) publications have been mapped in the past, we think it useful at this time to evaluate qualitatively the number, specialization, and scope of journals that publish scientific articles about fish. With this information, authors can match their work to the proper journal and readership. Using a broad review of the scientific literature that publishes articles on fish, we ask if the number of journals has changed over the past 25 years and if certain fish-related topics are increasing

at different rates. We also ask how existing fish-related journals are positioned in this present landscape relative to article type, application type, ecological system, taxa, and discipline. We use the term "publication landscape" throughout to mean the number of journals that publish fish-related articles, their breadth or specialization, and their relationship to each other. Based on these questions, we identify the steps for delivering fish-related articles to a journal where it has the best chance of being reviewed by people with the relevant knowledge and expertise to assess its strengths. Then, if accepted, we review the steps for maximizing opportunities to have the manuscript accessed, read, and utilized.

METHODS

We identified the number of journals that published fish-related research from 1980 until 2006 using the Institute of Scientific Information (ISI; http://scientific.thomson.com/isi) Journal Citation Reports® (JCR) online for 2003–2006 and through the Scientific Citation Index® (SCI) for years earlier than 2003. To determine if the number of journals increased over this time period, we tallied the number of journals for four JCR subject categories: fish and fisheries (fisheries, prior to 2003), marine and freshwater biology, ecology, and environmental sciences.

To assess whether particular research topics changed over time, we compared the number of articles between 1980–1984 and 2000–2004 for six sets of keywords that varied in historical context. We chose a well-defined topic that researchers have studied for many years, "Atlantic salmon" (*Salmo salar*); a well-established but currently dynamic technical area, "stock assessment;" a well-established technique, "mark-recapture;" a newer emerging concept, "watersheds;" a newer technical area that is currently very popular, "ecosystem-based management;" and an emerging technology, "acoustic tagging." Specifically, we searched the topic keywords above on the ISI Web of Science® for these two time periods. Except for Atlantic salmon, all key words were searched in conjunction with the keyword "fish." Atlantic salmon was searched alone.

To map the present landscape of fish-related journals, we examined a select but diverse list of journals published in 2006 (Table 1; N=60). Our goal was to use a broad scope to define the diversity of journals and identify specialized areas, but not to provide a quantitative analysis. This was a representative but select list. It included a wide range of journals spanning the major outlets for publishing articles on fish. We started with the JCR subject category "fish and fisheries" (FF; N = 41) and removed 20 aquaculture, disease, and regional journals (N=21 remaining). We added a range from ecology (EC; N= 17), marine and freshwater biology (MF; N = 10), environmental sciences (EN; N = 4), zoology (ZO; N = 3), multidisciplinary topics (M; N=3), and oceanography (OC; N = 2). Next, we mapped the boundaries of the publication landscape by classifying each journal by five separate criteria: article type (review or original data), type of application (if any), system, taxa, and discipline (Table 1). Journals in Table 1 were sorted hierarchically by application, system, and taxa. For example, after the review articles were listed, we sorted all journals that had a specific application. Then we sorted all journals with the same type of application. Within an application, we sorted the journals by ecological system. Within journals that have the same application in the same type of ecological system, we sorted journals by taxa. If journals had the same application, system, and taxa, we listed them alphabetically. In this summary, we tried to impose order but also retain the diversity and specialization of the present suite of journals that publish articles on fish. For classification of these journals, we used the criteria listed on the journal web page.

Regarding article type and application, we first classified journals as primarily review or original data. We only considered journals that published predominately review articles for the review classification, excluding journals that publish select reviews. Journals were then categorized into specific types of applications: i.e., fisheries, management, disease-aquaculture, or conservation biology, if those specific applications were explicitly identified on the journal web page as primary priorities. "Disease-aquaculture" was considered an applied category even though some disease journals publish a range of applied to basic articles. For explicitly applied journals that did not fit into the above specific categories, we used a "general application" category. When aim and scope did not explicitly identify a type of application as a priority, we did not impose a classification and these journals were not included in this "application" grouping. In general, journals were entered into a single type of application category. Two exceptions existed for journals that identified both "fisheries" and "management" as priority applications (i.e., *North American Journal of Fisheries Management* and *Fisheries Management and Ecology*). Journals containing only sections for applied features were not considered to be applied journals.

When considering the ecological system, we categorized journals into "marine," "freshwater," "aquatic," "any," and "special" categories. We categorized journals that dealt exclusively with aquatic systems as marine or freshwater if submissions were limited to one of these two types of systems or aquatic if both freshwater and marine were acceptable. We categorized the ecosystem as "any" if a journal encouraged submissions from both terrestrial and aquatic systems. Some journals limited the articles they publish to a specific type of ecosystem, in which case we categorized the journal as "special." For the categories "marine," "freshwater," "aquatic," and "any," journals were entered into the single, most specialized category as defined on the journal web page. Because we were interested in identifying emerging and existing specialization in fish-related journals, those classified as "special" were placed in the appropriate freshwater, marine, aquatic, or any category as well.

Regarding the taxa classification, we categorized journals into "fish," "aquatic," and "any" categories. The fish category included any fish regardless of its human use. "Aquatic" referred to any water-dwelling taxon and was used if fish was not the primary focus. The "any" category was used when any taxa (e.g., bird, mammal, fish, invertebrate) was an acceptable focus. Although fisheries journals publish articles on both exploited fish and invertebrates, these were classified as fish, not aquatic, unless the journal explicitly identified non-fish taxa as a priority (e.g., some aquaculture journals). Unless a journal explicitly encouraged multiple categories (e.g., Fisheries and Aquatic Sciences), each journal was listed in a single category.

When considering discipline, we classified journals as "ecology," "aquatic sciences," "fisheries science," "fish biology," "conservation biology," "behavior," "aquaculture," "disease," "oceanography," "physiology," "zoology," or "any." The aquatic sciences category included freshwater or marine science that may or may not include fish. "Fisheries science" included the body of scientific knowledge related to fisheries and their environment (Royce 1996). "Any" included general science that encouraged multidisciplinary submissions. Each journal was classified as specifically as possible for each priority identified on the journal web page. Laundry lists of disciplines on journal web pages were not considered journal priorities. With the exception of the generalist category, "any," journals could be

Table 1. For 60 journals, the specific type of application, system, taxa, discipline, impact factor, and JCR category are listed. Some journals are listed in multiple JCR categories. The process by which journals were classified is described in the text. The first four journals are review journals. All other journals are grouped hierarchically by first application, then system, then taxa. Within each combination of categories, the journals are alphabetized. Although not intended to be complex, the table reflects the real diversity and specialization of the present literature that publishes articles on fish.

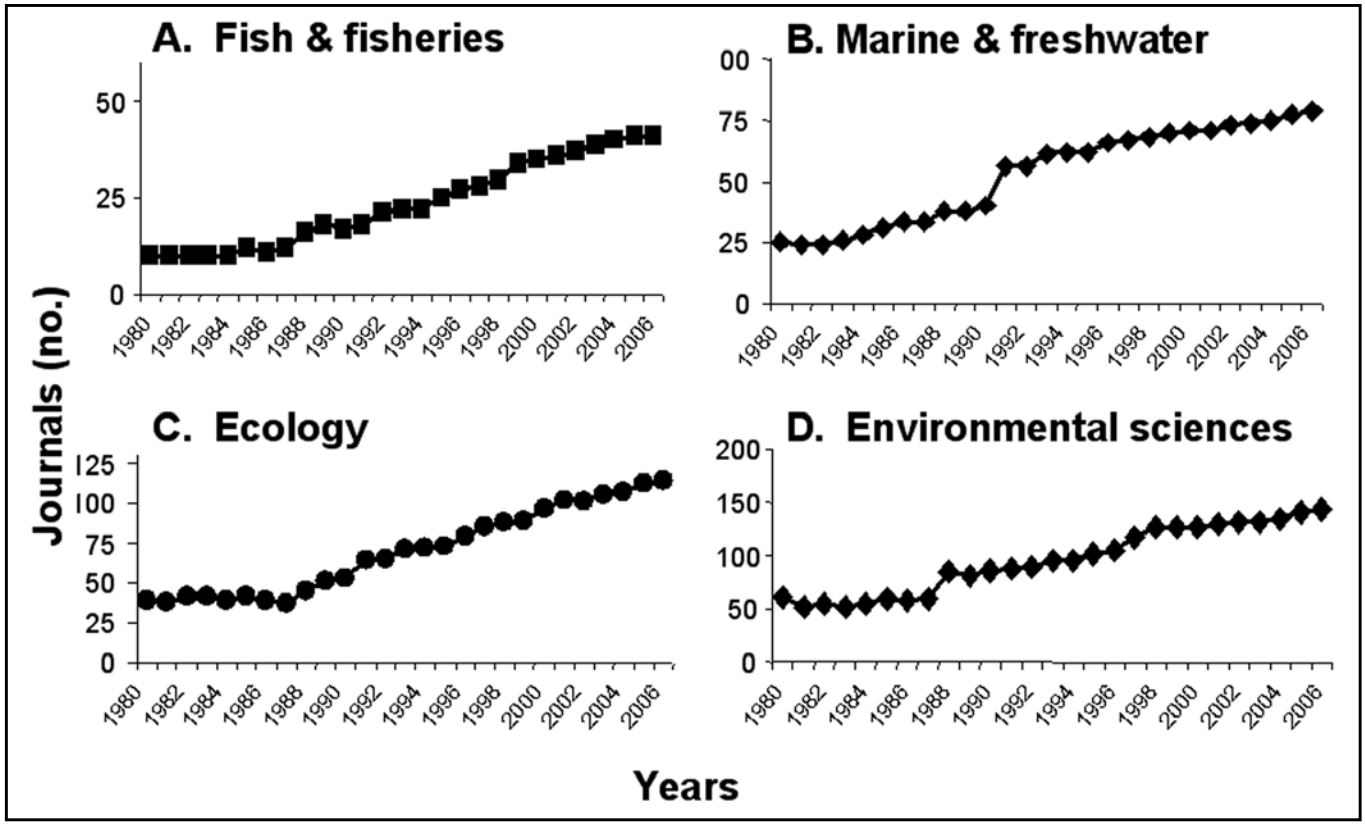
Journal Name	Application					System					Taxa			Discipline												Impact Factor (2006)	A JCR Category
	Fisheries	Management	Conservation biology	Disease / aquaculture	General application	Marine	Freshwater	Aquatic (freshwater and marine)	Any system accepted	Special systems	Fish	Aquatic (not just fish)	Any taxa (fish or other)	Ecology	Aquatic biology / science	Fisheries	Fish biology	Conservation biology	Behavior	Aquaculture	Disease	Oceanography	Physiology	Zoology	Any discipline accepted		
Trends in Ecology and Evolution (review)									■				■	■												14.125	EC
Fish and Fisheries (review)	■							■			■					■	■									4.257	FF
Reviews in Fish Biology and Fisheries (review)	■							■			■					■	■									1.512	FF
Reviews in Fisheries Science (review)	■							■			■					■										1.312	FF
Canadian Journal of Fisheries and Aquatic Sciences	■							■			■	■			■	■	■									1.882	FF
Fisheries	■							■			■					■										1.917	FF
Fisheries Research	■							■			■					■										1.216	FF
Fisheries Science	■							■			■					■										0.766	FF
Transactions of the American Fisheries Society	■							■			■					■	■									1.386	FF
Fishery Bulletin	■					■					■					■										1.403	FF
Fisheries Oceanography	■					■					■					■						■				1.832	FF
Fisheries Management and Ecology	■	■						■			■			■		■										1.371	FF
North American Journal of Fisheries Management	■	■						■			■					■										0.848	FF
Environmental Management		■							■				■												■	1.097	EN
Journal of Environmental Management		■							■				■												■	1.477	EN
Aquatic Conservation: Marine and Freshwater Ecosystems			■					■				■						■								1.350	MF
Biodiversity and Conservation			■						■				■					■								1.423	EC
Conservation Biology			■						■				■					■								3.762	EC
Aquaculture				■				■				■								■						2.081	FF
Journal of Aquatic Animal Health				■				■				■									■					0.921	FF
Journal of Fish Diseases				■				■			■										■					1.715	FF
North American Journal of Aquaculture				■				■				■								■						0.500	FF
Aquatic Living Resources					■			■				■			■											1.247	FF
ICES Journal of Marine Sciences					■	■						■			■											1.469	FF
River Research and Applications					■		■			■		■			■											1.645	EN
Ecological Applications					■				■				■	■												3.470	EC
Environmental Conservation					■				■				■					■								0.944	EN
Journal of Applied Ecology					■				■				■	■												4.527	EC
Bulletin of Marine Sciences						■						■			■											1.093	OC
Journal of Experimental Marine Biology and Ecology						■						■		■	■											1.919	MF
Marine Ecology—Progress Series						■						■		■												2.286	MF

Journal Name	Application					System					Taxa			Discipline												Impact Factor (2006)	A JCR Category
	Fisheries	Management	Conservation biology	Disease / aquaculture	General application	Marine	Freshwater	Aquatic (freshwater and marine)	Any system accepted	Special systems	Fish	Aquatic (not just fish)	Any taxa (fish or other)	Ecology	Aquatic biology / science	Fisheries	Fish biology	Conservation biology	Behavior	Aquaculture	Disease	Oceanography	Physiology	Zoology	Any discipline accepted		
Ecology of Freshwater Fish							■				■			■												1.479	FF
Freshwater Biology							■					■			■											2.502	MF
Journal of Freshwater Ecology							■							■												0.376	EC
Journal of Great Lakes Research							■			■		■			■											1.000	MF
Journal of North American Benthological Society							■			■		■			■											2.219	MF
Copeia								■			■													■		0.848	ZO
Environmental Biology of Fishes								■			■						■									0.934	MF
Journal of Fish Biology								■			■						■									1.393	FF
Aquatic Sciences—Research Across Boundaries								■				■													■	1.563	MF
Hydrobiologia								■				■			■											1.049	MF
Limnology and Oceanography								■				■														3.287	OC
Marine and Freshwater Research								■				■			■											1.439	FF
Estuaries and Coasts								■		■		■			■											1.563	MF
Wetlands								■		■			■		■											1.109	EC
Ecology									■				■	■												4.782	EC
Ecology Letters									■				■	■												7.609	EC
Ecosystems									■				■	■												2.955	EC
Frontiers in Ecology and the Environment									■				■	■												4.842	EC
Journal of Animal Ecology									■				■	■												3.390	EC
Oikos									■				■	■												3.381	EC
Oecologia									■				■	■												3.333	EC
Animal Behaviour									■				■						■							2.711	ZO
Behavioral Ecology									■				■	■					■							3.061	EC
Behavioral Ecology and Sociobiology									■				■	■					■							2.316	EC
Canadian Journal of Zoology									■				■											■		1.393	ZO
Journal of Experimental Biology									■				■										■			2.631	EC
BioScience									■				■												■	5.424	M
Nature									■				■												■	26.601	M
Science									■				■												■	30.028	M

placed in multiple categories if the journal web page specified these as high priorities. We based our categorization on the title of the journal and by the documents provided by the publisher on the journal web page (i.e., aim, scope, goals and guide to authors). Because the goal of our review was to tease out obvious specializations in the present landscape of journals, we were careful not to impose our own assessment of specialization. We believe our approach was the best way to begin identifying major journal groups that presently exist in the landscape.

As an example of one way journals are evaluated, we plotted the JCR impact factor, a measure of the frequency with which the "average article" in a journal has been cited in a particular year or period, for two prominent fisheries journals in North America from 1982 to 2006. These were *Transactions of the American Fisheries Society* (TAFS) and *Canadian Journal of Fisheries and Aquatic Sciences* (CJFAS). We also developed a flowchart of the publication process to guide

Figure 1. Change in the number of journals over time from 1980 through 2006 for the SCI JCR categories (A) fish and fisheries, (B) marine and freshwater biology, (C) ecology, and (D) environmental sciences.



authors in achieving their publication goals. In this graphic, we emphasized the perils authors may face in selecting appropriate journals for their material in a changing landscape and the challenges that published authors face in getting their research read and implemented.

To generate a comparative sense about how the number of manuscripts received, the proportion of manuscripts received that were reviewed, and the acceptance rate varied among journals, we sought this information for 2006 from all of the fisheries journals we identified in Table 1. Unfortunately, this information was not readily available from most journals. We also examined a subset of representative journals to determine whether: (1) they were indexed on the Web of Science, (2) current or archived volumes were available on line free of charge, (3) they were available online only, (4) who published the journal, and (5) the cost of page charges, if any.

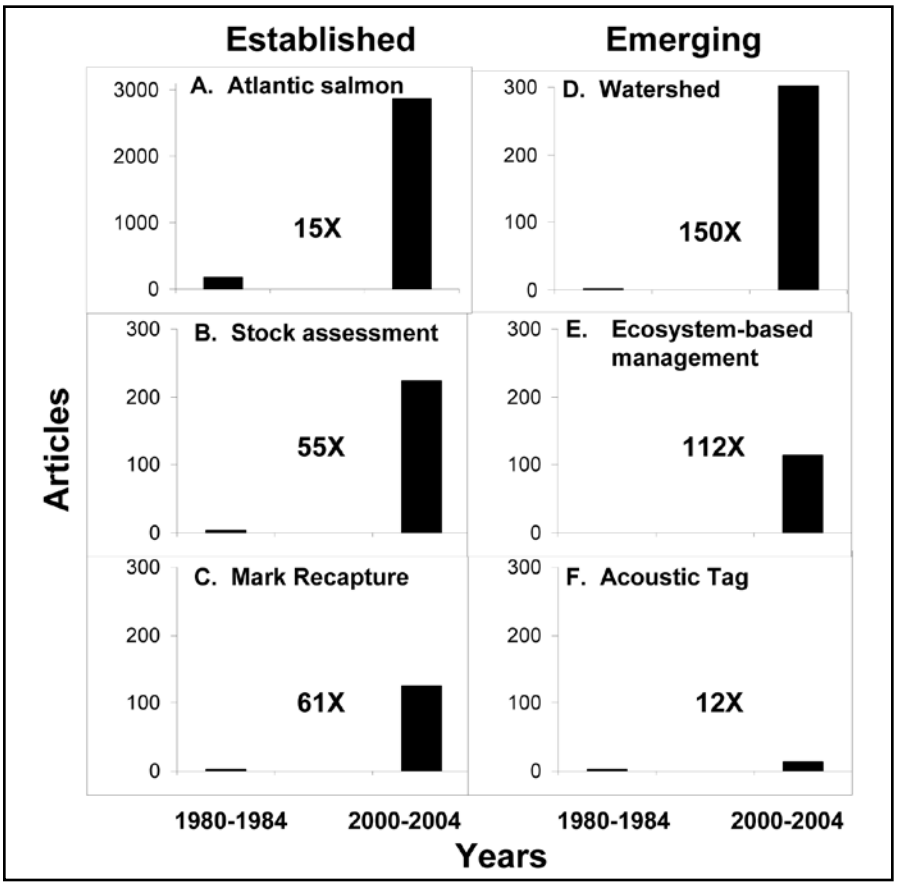
RESULTS

The exact number of journals in each of the four JCR subject categories varied (Figure 1). However, from 1980 to 2006, for all of the categories (fish and fisheries, marine and freshwater biology, ecology, environmental biology), the numbers of journals increased between 2.4 and 4 times regardless of initial and final numbers of journals (Figure 1A–D). For searches on established concepts (i.e., Atlantic salmon, stock assessment, mark-recapture), many more articles were published in 2000–2004 than in 1980–1984 (Figure 2A–C). Numbers of articles on these topics increased 15, 55, and 61X, respectively, indicating an increase in publications on established topics over the last 20 years. In the 1980s, articles on emerging concepts, i.e., watersheds, ecosystem-based management, and acoustic tagging were virtually non-existent. By 2004, these articles on emerging concepts were quite common and had increased by 150, 112, and 12X, respectively, suggesting that a number of new topics for fish-related research exist in the present landscape (Figures 2D–F).

Considering article and application type in the present landscape, the 60 fish-related publications we examined showed that only 4 journals primarily published review articles (Table 1). Of those that identified a specific application as a priority, many journals were explicitly fisheries (e.g., Figure 3A; any system—*Canadian Journal of Fisheries and Aquatic Sciences*, *Fisheries*—or marine fisheries—*Fishery Bulletin*; Table 1). Some focused on both fisheries and management (e.g., *Fisheries Management and Ecology*, *North American Journal of Fisheries Management*) or were broader management journals (e.g., *Environmental Management*). Some were dedicated to the applied discipline of conservation biology (e.g., *Aquatic Conservation: Freshwater and Marine Ecosystems*). Others sought contributions that had disease-aquaculture applications (e.g., *Aquaculture*, *Journal of Aquatic Animal Health*). A few journals requested general applications in aquatic systems (e.g., *Aquatic Living Resources*) or any system (e.g., *Ecological Applications*).

Regarding the ecological system, some journals sought only marine contributions (e.g., *Bulletin of Marine Sciences*, *Journal of Experimental Marine Biology and Ecology*) or restricted submissions to only those related to freshwater (e.g., *Ecology of Freshwater Fish*, *Freshwater Biology*; Figure 3B; Table 1). Many advertised themselves as being receptive to contributions from all aquatic ecosystems including both marine and freshwater systems (e.g., *Aquatic Sciences*). Other journals accepted contributions from any system, terrestrial or aquatic (e.g., *Ecology Letters*, *Ecosystems*). In addition, some journals tar-

Figure 2. Number of articles from 1980–1984 and 2000–2004 within established and emerging topics for six sets of keywords: (A) Atlantic salmon, (B) stock assessment, (C) mark-recapture, (D) watershed, (E) ecosystem-based management, and (F) acoustic tagging. We searched the topic keywords indicated above on the ISI Web of Science®. All key words were searched in conjunction with the keyword "fish," except Atlantic salmon, which was searched alone. The increase in number is indicated on each plot (N_{t2} - N_{t1}/N_{t1}).



geted special types of systems (e.g., *Journal of Great Lakes Research, Estuaries and Coasts, Wetlands*).

With reference to taxa (Figure 3C; Table 1), many journals were explicitly dedicated to fish that may (e.g., *Fisheries Research*) or may not (e.g., *Copeia*) be part of a fishery. A number of journals encouraged submissions on any aquatic taxa, including fish or zooplankton (e.g., *ICES Journal of Marine Sciences, Limnology and Oceanography*). For other journals, any taxa were acceptable as long as other criteria were met (e.g., *Journal of Environmental Management, Nature, BioScience*).

Examining discipline (Figure 3D; Table 1), journals that publish fish-related articles were diverse. Many journals focused on ecological research (e.g., *Journal of Applied Ecology, Marine Ecology—Progress Series*), aquatic sciences (e.g., *River Research Applications*), fisheries (e.g., *Fisheries Science, Transactions of the American Fisheries Society*), fish biology (e.g., *Environmental Biology of Fishes, Journal of Fish Biology*) or conservation biology (e.g., *Biodiversity and Conservation*). Some of the journals reviewed here specifically targeted behavior (e.g., *Animal Behaviour*), aquaculture (e.g., *Aquaculture*), disease-related research (e.g., *Journal of Fish Diseases*), zoology (e.g., *Canadian Journal of Zoology*), oceanography (*Fisheries Oceanography*), physiology (*Journal of Experimental Biology*), or a broad range of disciplines (e.g., *Science*). When these criteria were combined, some journals accepted a diverse array of general contributions from any discipline (e.g., *Fisheries Science, Aquatic Sciences—Research Across Boundaries*), whereas others were quite specialized (e.g., *River Research and Applications, Journal of Experimental Marine Biology and Ecology, Ecology of Freshwater Fish*).

Even with this matching of foci, many journals are quite competitive as assessed by the number of manuscripts received, reviewed, and accepted. For fisheries journals for which acceptance rate data were available, 18–62 manuscripts were annually submitted to review journals in 2006, of which 75–100% were reviewed (Table 2). For journals that dealt primarily with original data, annual submissions were higher (118–653) but the proportion reviewed was similar (64–96%). For common fish and fisheries journals, acceptance rates ranged from 30–83% for reviews and 30–69% for original data articles (Table 2). Number of issues published annually could affect the acceptance rate of space-limited journals. Most fisheries journals published between 4–12 issues per year (Table 2).

Impact factor varied widely from 0.4 to 30 (Table 1) and changed over time (Figure 4). For two fisheries journals, TAFS and CJFAS, the impact factor varied from 1982 to 2006. There was no clear trend in the impact factor of TAFS, with scores generally ranging between 1.0 and 1.5. There was a slight upward trend for CJFAS, with index scores remaining consistently above 1.5 since 1999.

Thus, clear differences existed among journals, shaping the landscape in which would-be authors find themselves. Several hazards impede the publication of even the most brilliant, flawlessly executed research. We think a flowchart may help an author navigate the confusing array of specialization and aid in the matching of one's manuscript to the aim and scope of the target journal (Figure 5A). Specifically, authors need to make strategic decisions on article type (review or original data), application type (e.g., no application, general application, fisheries, management, conservation biology), system (e.g., freshwater, marine, both, any), taxa (e.g., fish, invertebrate), and discipline (e.g., ecology, fisheries, fish biology, conservation biology) (Figure 5A, steps 1–6). Once the manuscript and the journal are matched based on these criteria, the author needs to evaluate the acceptance rate for his/her prospective journal and assess the chances that his/her manuscript would be accepted (Figure 5A, step 7). Then after the manuscript is submitted, the author can increase his/her chances of avoiding the rocks of rejection and having his/her manuscript accepted for publication (Figure 5A, steps 8–11).

Having a manuscript published does not mean, however, that the project will get to the right audience and that the manuscript will be read and used (Figure 5B; Table 3). To be read and used, an article needs to address an application, system, taxa, and discipline of the reader (Figure 5B, steps 1–6). Although these are the same steps as identified for publication, different readers may have different criteria for what applications, systems, and taxa are relevant to them as fishery professionals. Consequently, to be read and used, a manu-

Figure 3. The number of journals that currently publish fish-related research are shown classified by (A) type of application, (B) system (ecosystem type), (C) taxa, and (D) discipline. Categories for type of application include fisheries, management, conservation biology, disease-aquaculture, and general application. Not all journals were included in the specific type of application classification. Categories within system included marine, freshwater, aquatic (marine and freshwater), any (aquatic and terrestrial), and special (specific types of ecosystems). Taxa included fish, aquatic (fish and non-fish), and any (aquatic and terrestrial) taxa. Disciplines included ecology, aquatic sciences, fisheries, fish biology, conservation biology, behavior, aquaculture, disease, zoology, oceanography, physiology, and any discipline. Throughout, we classified the journals as specifically and exclusively as journal web page priorities allowed.

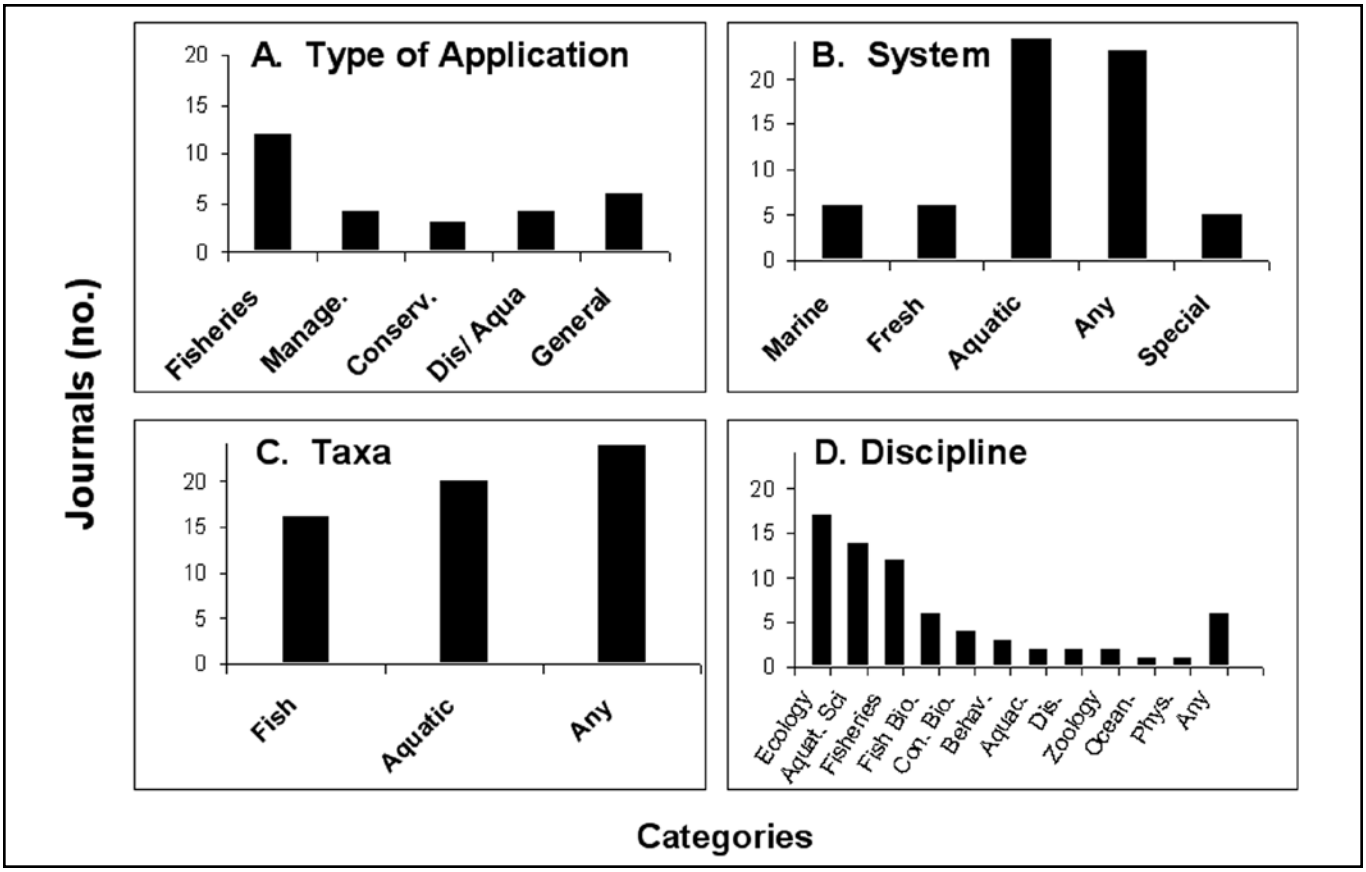
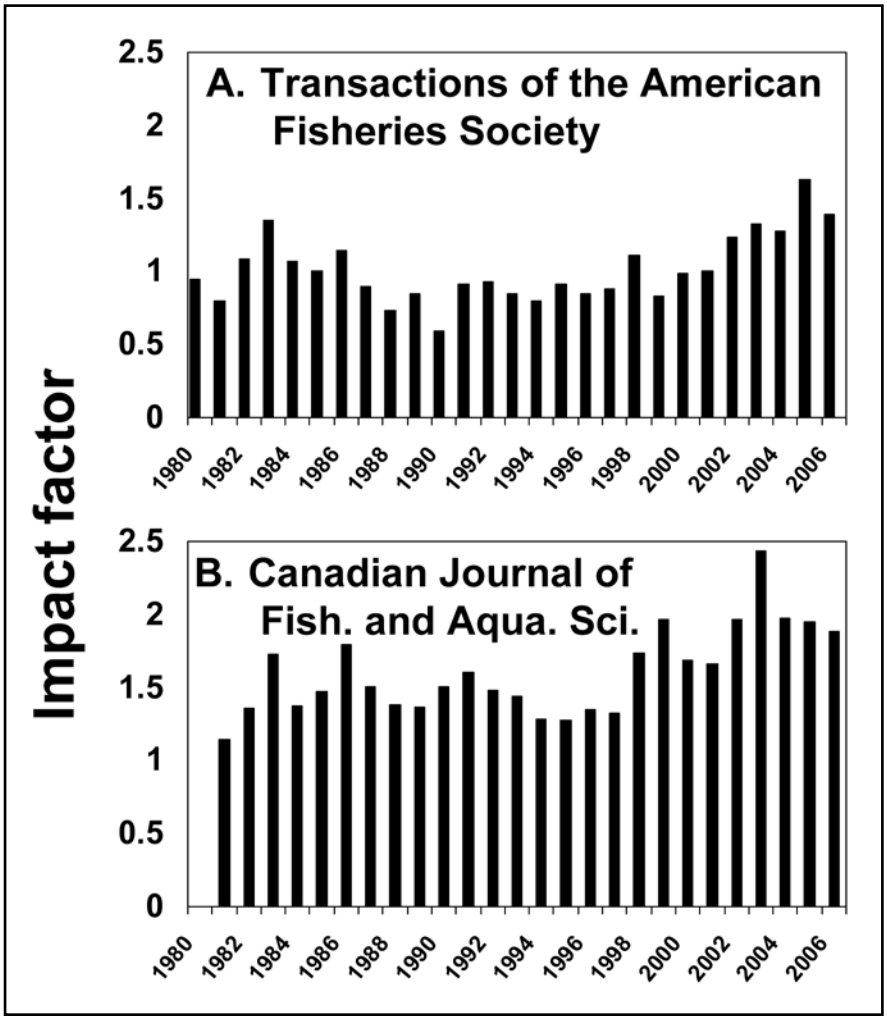


Table 2. This subset of both review and original data journals from Table 1 shows competitive criteria that may affect whether a paper is published. For 2006, these include number of manuscripts received, number of manuscripts reviewed, acceptance rate and number of standard issues per year. These were the only fisheries journals for which these data were available.

Journals	Manuscripts Received to Review 2006	% Reviewed 2006	Acceptance Rate 2006	Number of Issues Per Year
Fish and Fisheries (Review)	62	75%	30%	4
Reviews in Fish Biology and Fisheries	35–40	89%	50–60%	4
Reviews in Fisheries Science	18	100%	83%	4
Canadian Journal of Fisheries and Aquatic Sciences	653	64%	30%	12
Ecology of Freshwater Fish	200	90%	40–50%	4
Fisheries Management and Ecology	118	85%	42%	6
North American Journal of Fisheries Management	285	95%	69%	12
Transactions of the American Fisheries Society	268	96%	68%	12

script should address the special interests of the readers (Figure 5B, Step 7). Furthermore, the reader needs to be able to access the journal (Figure 5B, step 8). To be accessible, articles need to be indexed so they can be identified in a database search and recent and archived issues should be available online for free (Table 3). Most journals were indexed by a major service such as Web of Science®. The journals that were consistently available through the journal web page for free varied widely. In some cases, no articles were available without a subscription. In other cases, recent (*Fisheries*, *Estuaries and Coasts*) or older issues (*ICES Journal of Marine Sciences*, *Marine Ecology—Progress Series*) could be accessed for free. Few established journals were solely online journals. Although many publications were in transition relative to these characteristics, accessibility could depend on whether a journal was sponsored by a professional society or a for-profit publisher (Table 3). Publication cost could affect accessibility. Increasingly, journals allow authors to pay in advance for open access in order to make their manuscript available to all readers for free. In general, publication costs varied widely across journals

Figure 4. SCI JCR impact factors over time for (A) Transactions of the American Fisheries Society and (B) Canadian Journal of Fisheries and Aquatic Sciences from 1980–2006.



from free to nearly $3,000 for the average article (Table 3).

DISCUSSION

We have shown that change has occurred in fish-related journals. We have also shown that this change has resulted in a complex, present-day publication landscape with substantial specialization by application, ecological system, taxa of interest, and predominant discipline. Likely, no one is surprised by the increasing number of journals, number of articles on all topics, or emergence of new concepts. Although the amount of specialization in any single grouping is not surprising, some novel insights have emerged by examining the magnitude of specialization when all of these classifications are evaluated together.

Considering the three key issues of application, conservation, and fisheries, this specialization may reflect real paradigmatic differences, not just semantics. Basic and applied research is clearly a continuum (Hoffman and Deffenbacher 1993). Not all research needs to be applied to be useful to society. However, deriving commonly agreed upon definitions of basic and applied would be useful because scientists may think they are conducting applied research of great utility to managers, while managers may find this so-called applied research esoteric (Parrish et al. 1995). Without continued and explicit communication on what is basic and applied between scientists and environmental professionals/policymakers, this divide between research and practice will not be bridged (Sutherland et al. 2006).

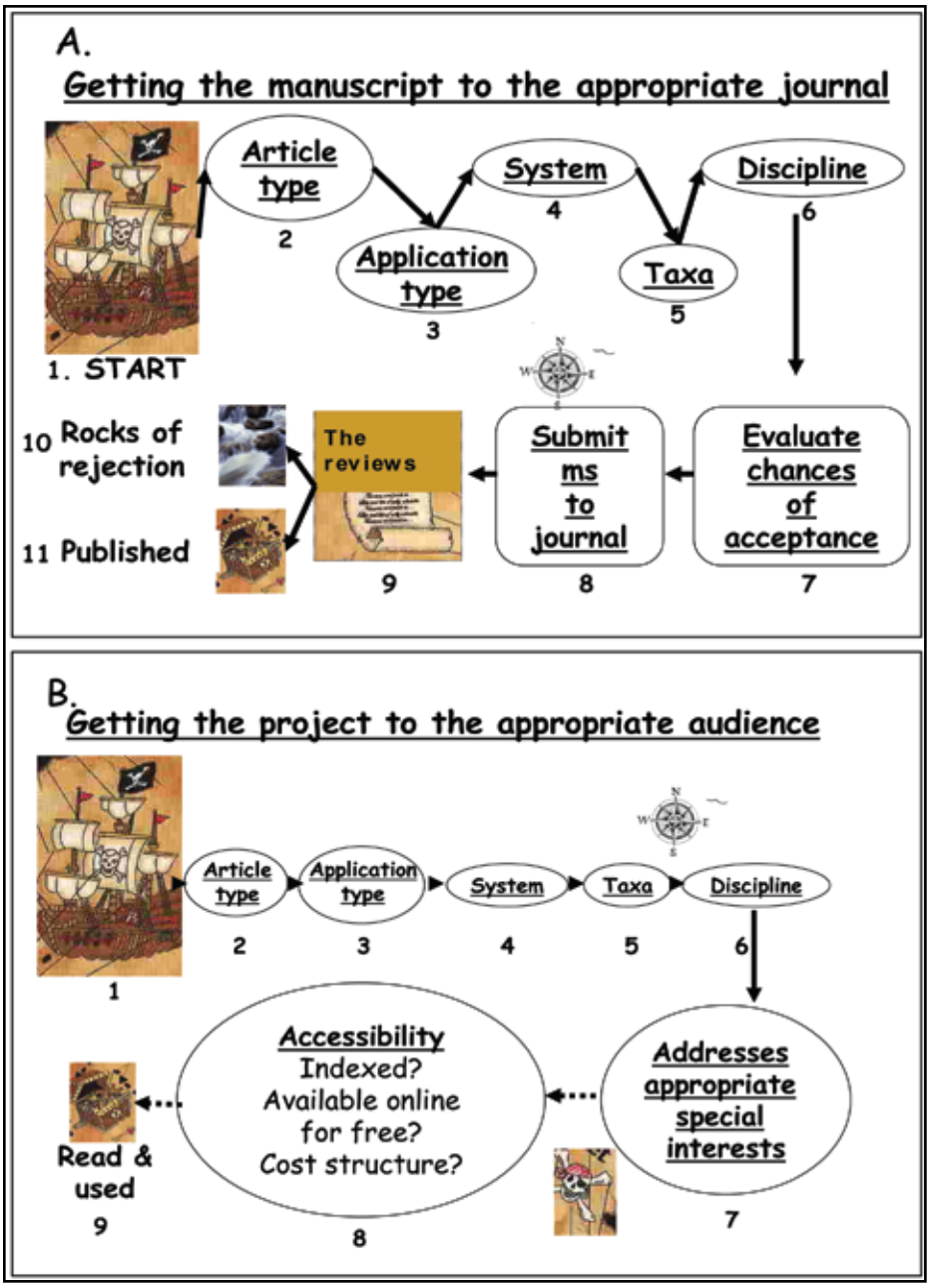
Likewise, we think real differences exist in the way conservation biologists define conservation as compared to the historical way conservation has been used in fisheries management (Noss 1999). This distinction may be increasingly related to changes in core values and philosophy (Kessler and Thomas 2006). For example, calculating harvest of natural resources is a secondary consideration (if it is considered at all) for conservation biologists, yet exploitation, viewed as recreational and commercial catch rates, is a fundamental aspect of traditional fisheries conservation. Although conservation regardless of the field is related to human values, fisheries conservation implies some very specific human management responses to depleted stocks, often reduced through fishing or other human alteration of habitat. Clarifying exactly what is meant by conservation across the two disciplines could improve fit among authors, journals, and users of the information.

Finally, differences may exist between journals focusing on fish and those concentrating on fisheries (Royce 1996; Walters and Martell 2004; Brown and Guy 2007), yet there are inconsistencies in the way these terms are used. Fisheries have a historical basis in population dynamics, human use, and the need to determine exploitation levels (Magnuson 1991). This legacy may cause fish and fisheries biologists to evaluate priorities and scientific quality differently, possibly resulting in a mismatch between what is submitted and what is published. We propose that variations in the paradigms and methods between areas such as fisheries, fish biology, fish ecology, fisheries ecology, fisheries science, and fisheries oceanography can be quite important, but are rarely explicitly identified.

Conducting high quality research is difficult enough by itself. The complexity of the publishing landscape and the difficulty of matching a project to an appropriate journal outlet makes it even more difficult for authors to get their manuscripts into publication. Just as sailors took frequent soundings to avoid the perils of sailing uncharted waters, there are steps an author can take to avoid running up on the rocks. These steps include clarifying the changing contours of the publication landscape and identifying paradigmatic and methodological matches and mismatches between their research and potential publication outlets. Our conceptual framework suggests that authors need to compare their topic and approach to the journal aim and scope; match the system, taxa, and discipline to the journal's prior content and objectives; then consider the likelihood of publication based on perceived chances of a manuscript being accepted.

An example using lake trout (*Salvelinus namaycush*) may help illustrate the need for using a conceptual framework to match a specific manuscript to a specific journal.

Figure 5. Flowchart showing the steps needed for A. Getting the research to the right journal (steps 1–10) and B. Getting the research to the appropriate audience (steps 1–8).



Lake trout is a freshwater predator widely distributed across northern latitudes of North America. The first steps in using our flowchart for publication (Figure 5) are to assess the article and application types. Although lake trout could be the subject of a review, most biological publications are original, data-based research publications (Figure 5A, step 2). An article on lake trout could also be purely science-based or it might have a specific application. Because lake trout is an exploited fish in many systems, a paper on lake trout likely would have applications to fisheries (Figure 5A, step 3). Many aspects of this species are relevant to both fisheries research and fisheries management. Studies appropriate for focused fisheries and fisheries management journals might include traditional fishery data on size, growth, and recruitment of lake trout or research that assesses parameters for stock assessment models. Because lake trout are freshwater fish, the choice of journals based on system and taxa is relatively limited (Figure 5A, steps 4, 5). Determining the discipline of a potential manuscript on lake trout is more complex as many options exist and the best fit may depend on how the research is framed (Figure 5A, step 6). Manuscripts on diets and food web dynamics might be suitable for fisheries and fish biology journals. A focused fishery journal might reject a study on links between lake trout, their prey, zooplankton, benthos, and temperature regimes, whereas a journal of aquatic sciences might readily accept it. When the paper is matched to application, system, taxa, and discipline, the author should assess the chances of his/her data being accepted by a range of journals. For example, a quarterly journal or an international journal may be less likely to accept the manuscript than a regional or monthly one (Figure 5A, step 7). Ideally, the criteria for acceptance by the journal are the same ones that the intended reader uses (Figure 5B). These few examples demonstrate how following the steps we have outlined may help authors navigate the range of journals appropriate for a given article.

An author's reason for publishing may affect the choice of outlet. Relative to professional advancement, number of articles published and prestige of the journal in which they publish are often ways a professional's job performance is evaluated. If prestige is the paramount concern (as might be the case in a tenure or promotion decision), scientists might want to publish in the journal with highest impact factor. If advancing scientific knowledge for the general community of scientists is the chief reason for publishing, certain outlets (*Fisheries*, *BioScience*, *Science*, *Nature*) would be best for reaching a broad range of scientists. To reach scientists in a specific technical field, an author may choose a journal based on its aim and scope as well as for its reputation as being an authority on a specific issue. *Transactions of the American Fisheries Society* and *Canadian Journal of Fisheries and Aquatic Sciences* are widely read by fisheries scientists even though they may not reach a wide scientific audience.

A final reason to publish is to make science more available to managers, stakeholders, and policy makers who will use it to solve environmental problems. To have publications accessed, read, and utilized are increasingly common objectives of journals and authors. Authors and journal editors would both like to know how many fisheries and environmental managers read their papers and incorporate their research into practice. The JCR impact factor is the dominant metric to track publications. Many aspects of scientific quality and readership are not incorporated into this measure. Some feel this single index is "tyrannizing" science and scientists. Relative to this, a current debate is underway as to whether JCR impact factors are the best way to track research productivity (Agrawal 2005; Monastersky 2005; Wilson 2007) and if there are better ways to quantify citations (Hirsch 2007). On the one hand, a way to quantify and track publications is needed, on the other hand, indices besides JCR impact factor that provide a more balanced picture of the utility of publications would be useful.

Whether publications are read and utilized is even more difficult to assess, because managers

Table 3. For a subset of journals from Table 1, listed are factors that may affect whether a published manuscript is read and used. The factors include whether the journal is indexed on a standard bibliographic database (i.e., Web of Science), whether the most recent and archived issues are all available on the journal web site for free, whether the journal is solely an online journal, publisher/sponsor, and page charges (based on web page information), for information available in 2006. Access is challenging to determine as many universities and other institutions have purchased access not available to the general public. To simulate access by professionals without individual or library subscriptions, we attempted to download the full text of current and archived articles from a public library. For an article to be published as open access, there is usually a one time charge to the author that allows anyone to read and download the article. Although many journals have free issues interspersed in their standard volumes, these were not considered as free access.

Journal	Indexed—	Available online for free		Online	Publisher/sponsor	Publication charges
	Web of Science	Recent	Archived	only		
Fish and Fisheries	Yes	No	No	No	Blackwell	Open access, $2600
Reviews in Fisheries Science	Yes	No	No	No	Taylor & Francis	None
Ecological Applications	Yes	No	No	No	Ecological Society of America	$60 per page
Journal of Environmental Management	Yes	No	No	No	Elsevier Science	None
ICES Journal of Marine Sciences	Yes	No	Yes, 1996–2007; No, < 1995	No	Oxford	
Fisheries	Yes	Yes	No	No	American Fisheries Society	$85 per page
Canadian Journal of Fisheries and Aquatic Sciences	Yes	No	No	No	National Research Council	None
Transactions of the American Fisheries Society	Yes	No	No	No	American Fisheries Society	$75 per page
Fisheries Management and Ecology	Yes	No	No	No	Blackwell	Open access, $2600
North American Journal of Fisheries Management	Yes	No	No	No	American Fisheries Society	$75 per page
Marine Ecology—Progress Series	Yes	No	Yes, > 4 years	No	Inter-Research Science	None
Ecology of Freshwater Fish	Yes	No	No	No	Blackwell	Open access, $2600
Estuaries and Coasts	Yes	No	No, 2002–2006; Yes, 1960–2002	No	Coastal and Estuarine Research Foundation/ Springer	Open choice
PLoS (Biology)	No	Yes	Yes	Yes	Public Library of Science	$2850

often do not publish and, therefore, we have no index for how often published insights are used by managers, policymakers, and researchers outside of citations. Currently, environmental professionals search literature by computer, so tracking the number of downloads from different web sites could be a good measure of articles being read (e.g., *Estuaries and Coasts* web page). Furthermore, many journals are now evaluating their own impact (Hobbs 2007) and how to address these issues (ESA 2007).

Is the present increase in fish-related publications helping to advance science by providing better information that is tailored to specialized users or just filling journals with higher volumes of less useful information, making pertinent information more difficult to find? The goal of this review is not to answer these value-based questions, but to emphasize that these issues need to be strategically addressed in order for research to remain effective in our changing world. Researchers and managers who work with fish can be proactive in shaping this change by making a conscientious effort to consider the broader publication landscape as they write, review, and read fisheries articles. ⚓

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COLUMN:
GUEST DIRECTOR'S LINE

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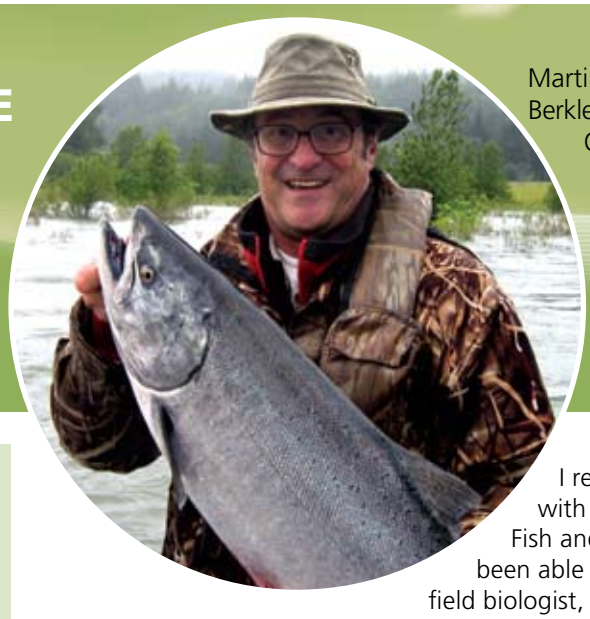
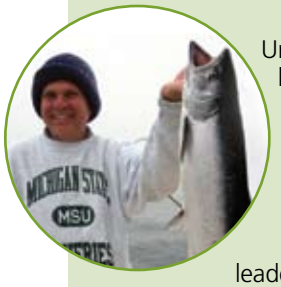
Leadership: A Tale of Six Mentors



This paper is the result of extensive discussions with **Bill Taylor, Katie Kahl, Nancy Leonard, and Jordan Burroughs** at Michigan State University regarding the lessons learned by Jim Martin throughout his extensive and colorful career with fishery related state and industry sectors. Jim is an inspirational leader, friend, and mentor to all who have the opportunity to interact with him. There is no way to adequately replicate in a manuscript the enthusiasm, sincerity, and urgency that Jim personally brings to a conversation about the state of our world's natural resources, the need for fisheries conservation, and the essence of leadership that he says are needed to "move the needle!" His sentiments on leadership are recorded here in his voice, as a motivating message to everyone from young and aspiring students to mid-career professionals to retired administrators. You can watch Jim's presentation in video format at www.fw.msu.edu. This is the inaugural speech of an ongoing set of presentations provided under the auspices of the Sustainable Global Fisheries Systems program at Michigan State University.



Nine years ago, I retired after a 30 year career with the Oregon Department of Fish and Wildlife. Since then I've been able to reflect on those years as a field biologist, fish researcher, harvest manager, chief of fisheries, and governor's advisor. My reflections have centered on asking, "*How much of all that work really mattered?*" What portion of my efforts and passion were spent on what someone else saw as the urgent, while the important and meaningful got away from me? (as Stephen Covey would say in *The 7 Habits of Highly Effective People*).

WORK MAGIC

As I think about the best times in my career, they were all spent experiencing an excitement and happiness in my work…times I term "work magic." The rest of the times were just work. There is a dramatic distinction between work magic and just work. The paradox is that in work magic times, I was working harder and longer than any other time in my life, and yet I loved it.

What if we could understand the factors that combine to create work magic and could purposely "dial it in?" Think of the energy and productivity that would result from working in the state of work magic more often than not! There were six periods of my career when I was in the state of work magic. I have pondered what was unique about those times and how can I pass this knowledge to others. The following is my assessment of the key variables needed for work magic.

There are three indispensable components of work magic. First, we must have **meaningful work.** We all get into resource conservation to make a difference in those parts of nature that capture our imagination and our passion. Somewhere along the line though, we find ourselves buried in the bureaucracy of government, non-profit, or private organizations. Think of the work you have done over the last six months…over the last five years…over your career. Can you say that you are making a difference for the environment and the conservationists who love and interact with nature?

In order to be in the state of work magic, we need to be able to see a direct link between our day-to-day efforts and the resource. Are we "moving the needle" towards sustainable resource use? Are we making a difference in peoples' lives and in the environment? If not, why not? Isn't this why we got into this field to begin with?!

The second component of work magic is **fun.** Not fun that accidentally breaks out and is quickly suppressed like a wildfire, but fun that is on purpose. This is fun that is planned as a daily part of the work we do. When was the last time you belly laughed and had fun at work…on purpose? For some, probably most, of us it has been quite a while.

The third component of work magic is **great leadership.** Find a team of maniacs, working like crazy on a resource issue, and at the center you will find an inspirational leader. This leader believes in the cause with all of his/her

heart and soul and connects with and ties together each member of the team. Leaders wear passion for their work like a name badge.

LEADERSHIP IS THE KEY

What are the characteristics of great leaders? Are they made or born or some combination of both? Consider for a moment the person who comes to mind as the great leader, the great mentor, of your life and what characteristics they exhibit. We will come back to that person later in this essay.

In my life, I have had six great mentors who showed me all I know about leadership. These are people that created defining periods of work magic in my career. Each has a different personality and each taught me a different lesson of great leadership.

In 1969, I graduated with my bachelor's degree in wildlife management from Oregon State University and went to work on the lower Rogue River for one of the great leaders of my life, **Fred Everest.** He was leading the research crew in southern Oregon, studying the famous summer steelhead of the Rogue River. The work was setting a seine, capturing fish, sampling and tagging them, and releasing them to continue their migration up the Rogue. The work was hot, long, and exhausting. We would set the seine time after time hoping to capture the migrating fish and attach the tags that would decipher the code of their life history, migration timing, and habitat requirements so we could ensure their sustainable management in the years to come.

From this work with Fred, I learned the first lesson of great leadership:

There is no substitute for enthusiasm!

We worked until we were so tired that we could hardly stand and then Fred would want to set the net once again. We would work past quitting time, because he saw fish breaking the riffle and entering our sampling area, his enthusiasm so great for learning about these fish…and it never occurred to him that we would not set the net again. We always followed him because he was first on the boat, first grabbing the net line and first to start sampling the fish—who were we to let him down? Enthusiasm fuels the team when the equipment breaks, the weather turns sour, and the days are long.

In 1972, I went to work for **Jim Lichatowich,** the second great mentor in my career. Jim was leading a team to evaluate the impacts of a series of hydropower dams on the Rogue River fishery. Jim had a more reserved personality than Fred Everest but he demonstrated a questioning and keenly insightful mind. He taught us, by his example, the second key principle of great leadership:

Think about the problem,
before rushing to a solution.

So often, because we are scientists, we treat every resource problem as a scientific problem. We rush to solution and can't understand why the political system and society in general doesn't respond immediately to our recommendations. Sometimes the problem is economic or political rather than just biological. The reality is that economics always trumps science and politics always trumps both. Some are discouraged by this message until they realize that their science can emphasize economics and change the politics by influencing public opinion. This communication is at the heart of making a difference.

By his example, and in his book *Salmon Without Rivers*, Jim taught me the importance of taking time to understand the historical trajectory of a problem and its context in the landscape (Lichatowich 2001). Only then can you really contribute to a solution in a meaningful manner and timeframe. Every problem has a "here and now" component and is also affected by things that happened a long time ago and a long way away from here. Taking the time to consider the nature of the problem is a trait that Jim Lichatowich exemplified.

In 1975, I returned to Oregon State University to seek a master's degree in fisheries, and went to work for the third of my great mentors, **Carl Shreck.** Carl lead the Oregon Cooperative Fishery Research Unit at OSU and every one of his students held him in high regard.

At that time, the rage on campus was "critical thinking" and many used that mantra as an excuse to show how smart they were by criticizing to the extreme everything and everyone. "We are smart and they are dumb and we know that because of our critical thinking"…sound familiar? Have we heard a lot of that in our place of work, in our personal life? Did it build energy or drain it? Did it contribute to solutions or add to the problems?

Carl Schreck rejected that attitude and instead pointed out that all that unnecessary "bad mouthing" will come back to haunt people who work in a small world, where "what goes around comes around." He knew that hurt feelings create long-term, deep-seated animosities that get in the way of teamwork needed for enhancing resource management. Negative attitudes rarely lead to progress in conservation. Carl led by example through rarely expressing negative feelings towards other professionals. He set a positive attitude and demonstrated that:

Positive demeanor is the key to positive energy in the workplace.

A focus on ideas over personalities is a critical component of great leadership.

In 1982, I went to work for **Harry Wagner,** chief of fisheries for Oregon Department of Fish and Wildlife (ODFW). We were in the middle of the political tornado known as the "Salmon Wars." In 1977, the North Pacific Ocean had changed regimes and ocean survival for many salmon stocks had plummeted to all time lows. Ocean survival for Oregon coho salmon dropped from 16% to 1.6%! In essence the resource had collapsed, necessitating the department to either close or severely reduce ocean fisheries in an effort to maintain spawning numbers. We, as fisheries biologists, didn't know what had happened. An unexplained change in population numbers had occurred and demanded conservation action…right now! We did not think of anything but the fish populations whose demise seemed near.

The political controversy over our biologically-based decisions was vicious. The department was accused of everything from incompetence to graft. Stupid was the nicest thing said and it went downhill from there…and it got nasty and personal.

In the middle of the controversy, Harry Wagner would tell us,

The test of a professional is not what your supporters think of you… it is what your opponents think of you.

Harry Wagner was the consummate gentleman, professional, and scientist. He never spoke down to anyone. He was patient, empathetic, and courteous. When he had bad news to deliver, he went out of his way to go to the opponent's place of work and deliver the news with respect and courtesy, no matter how he was treated. He never lost his sense of professionalism and his calm demeanor. Years later, when I was chief of fisheries with plenty of controversy swirling about the decision we made, I remembered Harry Wagner's quiet and kind example of how to work with people under pressure.

When Harry retired, people from all walks of life came to speak well of him. Many disagreed with Harry but no one ever was treated disrespectfully and everyone remembered it all their lives. Harry Wagner was the consummate chief of fisheries and a great mentor to many.

During this same time, Harry and I worked for one of the greatest directors of ODFW, **Jack Donaldson**. He was the director during the Salmon Wars. We all loved and respected Jack for the scientist, resource manager, and kind person that he was. During this very difficult time in the agency's history, Jack was viciously attacked by fishermen, politicians, and the media. He was accused of selling out the fishermen and the resource, while all the time trying to protect both for the future.

One time, Jack was the subject of a major public demonstration where fishermen burned him and our governor in effigy on a burning commercial fishing boat. The media covered this demonstration widely and the accusations were extraordinarily nasty, brutal, and unfair, both professionally and personally. The department staff was furious and wanted to launch a media counterattack. Jack called us together and waited for us to quiet down. He then began to describe how it must feel if all you knew was fishing on the ocean…risking your life to provide food and income…your only security was your boat…which was now worthless because the season was shut down. What if *we* had no salary or retirement benefits, he asked. How would we explain to our families that the boat was worthless, the season was shut down, and no one could explain exactly why or for how long? The quiet in the room was deafening! Then he explained something I have never forgotten,

They are mad as hell because they are scared to death!

Years later, when I was chief of fisheries and facing a mad crowd, anger seething from their bodies, I saw scared people and tried to empathize with them. I attempted to treat them with the same respect as Jack Donaldson and Harry Wagner would have.

In 1996, after six exhausting years as chief of fisheries at ODFW, I was offered the opportunity to work with **John Kitzhaber,** the then newly elected governor of Oregon. In spite of my built-in disdain at that time for any politician, I went to work for a person who turned out to be one of the great leaders and mentors of my life. As a biologist, I would have never predicted it!

Oregon stocks of coho salmon had been proposed for listing under the Endangered Species Act and Governor Kitzhaber wanted to avoid the social, political, and biological gridlock that had accompanied the listing of the northern spotted owl in the Pacific Northwest a decade earlier. We thus launched the Oregon Plan for Salmon and Watersheds, a state-based recovery strategy for fish and water quality in Oregon (OCSRI 1997). The plan continues to this day.

I learned a huge lesson about leadership one day at Governor Kitzhaber's staff meeting. While the governor was enthusiastically describing his vision for the state's education plan to his team, he was interrupted by his chief of staff, announcing that U.S. President Bill Clinton was on the telephone wishing to speak to him. We were so impressed that the president of the United States would call our governor. The governor got a pained expression…thought a moment…and told the chief of staff to tell President Clinton that *he would call him back!* We were flabbergasted and speechless. In that moment, I thought, "He just told us we were more important to him

than the president of the United States…now, which of us is ever going to disappoint this person?!"

The leadership lesson of that moment was that:

People are not really motivated by money, power, or fear of a bad performance appraisal—they are motivated to never disappoint someone they respect and love.

When we treat people with that respect, they will never forget the moment and will damn near die to avoid disappointing that kind of leader and mentor. To this day, former Oregon staff members speak of that day and their love and respect for former Governor John Kitzhaber.

YOUR GREAT MENTOR… HAVE YOU SAID THANKS?

Consider the person that I asked you to picture as the great leader or mentor of your life. It might be a parent, a boss, a teacher, or a major professor. Have you thanked them? Don't wait until it's too late. Tell them now, not at their funeral. Don't wait for everyone to be gathered around, telling stories of the dead leader with you kicking yourself for missing the opportunity to say thank you. Find them now. Track them down. Tell them what they have meant to you and you will not believe the look in their eyes and the feeling in your heart.

There is one other way to say thank you—consider how you are leading and mentoring as you pass it on. We are all leaders in our workplace, in our family, in our community. What kind of leader are you? Do you think about your leadership qualities daily? Would your mentor be proud? There is still time to make a difference, to make your mentor proud, and make the world a better place in which to live.

YOUR WORK, YOUR PASSION AND YOUR CAREER… IS IT MAGIC?

We are all responsible for our careers and how we use our energy, our time, and our passion. Think back over the last six months. Are you in work magic? Are you doing meaningful work that will matter when you look back on your career at your retirement? Are you belly laughing enough and are you having fun? Are you working for an inspirational mentor? If not, why not?

The difference between a manager and a leader is that the manager does things right (correctly) and a leader does the right things. Most of us are competent enough that we will do a fair-to-good job of what we choose to do. The key is whether we choose to work on the meaningful things that will matter and make the difference in the long run for the resource and for people. The most important decisions we make in our careers are what we will work on, what we will pass on, and the team we will work with. All the rest are relatively small details in the scheme of life.

When I retired nine years ago, I made two promises to myself. First, that I would do the best conservation work of my life in the next 20 years…I consider my first 30 years at the Oregon Department of Fish and Wildlife as my "undergraduate" work. Secondly, if the opportunities presented aren't both meaningful and fun, I will not do it. I will not give my remaining energy and passion to tiresome and trivial issues—don't have to, and damn well won't!

You *deserve* work magic. If you have already had it, you want and need more; it's addictive. If you haven't had it yet, keep looking. You won't forget it all your life and you will make the difference for the resource and it will provide you with the growth opportunities and fulfillment you deserve.

Take responsibility…work magic…go get it! ⚓

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WRAP-UP: A CAPITAL MEETING IN THE CAPITAL CITY

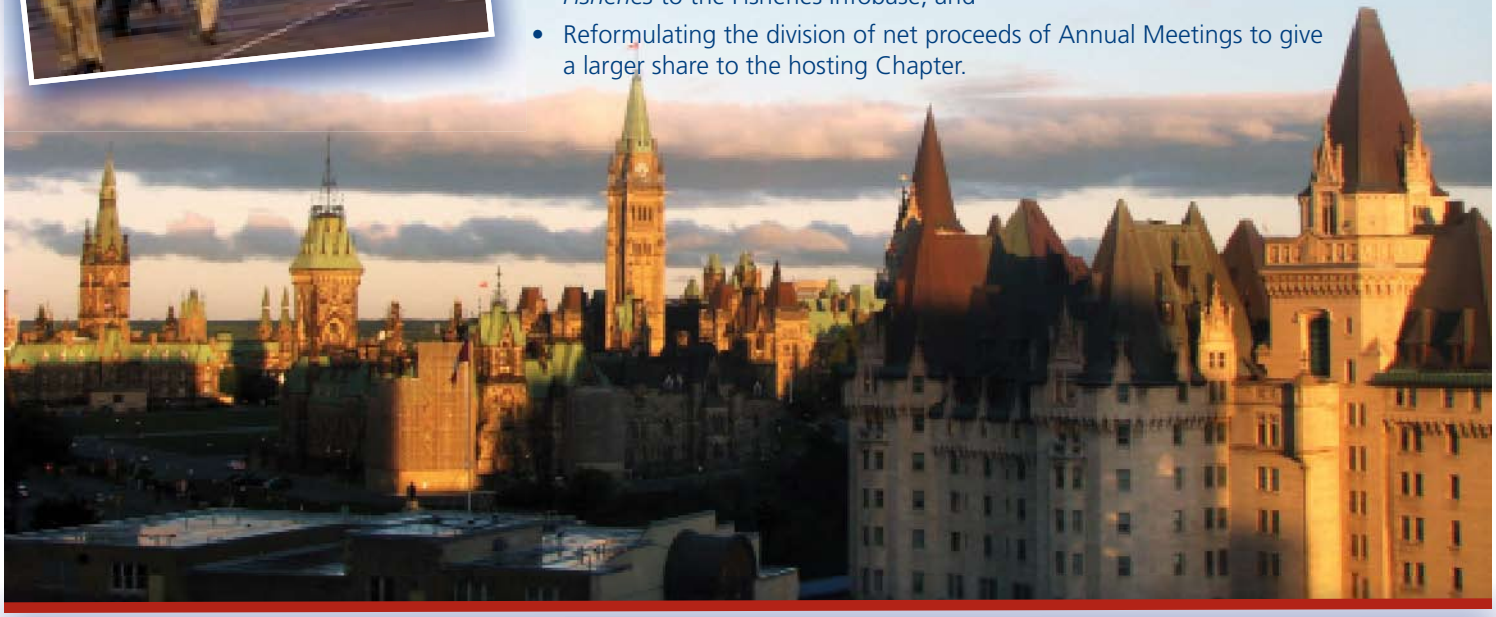
by Beth Beard

American Fisheries Society • 138th Annual Meeting
August 17-21 2008 • Ottawa • Ontario

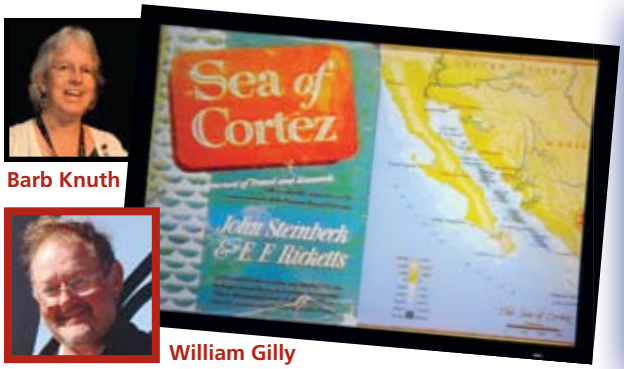
Ottawa, the capital city of Canada, also became the fisheries science capital of the world from 17–21 August, as 1,953 fisheries professionals, students, and guests gathered for the 138th AFS Annual Meeting. With scenic views of the historic Rideau Canal and Parliament Hill, and within easy walking distance of Byward Market nightlife, attendees were able to enjoy the city's most famous sights when taking a break for a summer stroll between sessions. This year's meeting theme was "Fisheries in Flux: How Do We Ensure Our Sustainable Future?"

A few days before the official start of the meeting, the AFS Governing Board gathered for a retreat at a nearby lodge to start the next five-year strategic planning process. Items on the agenda at Saturday's official Governing Board meeting that were passed included:

- Initiating a strategic planning process for the World Council of Fisheries Societies,
- Approving AFS constitutional revisions to allow electronic online voting and formation of joint Student Subunits with other societies,
- Changing the name of the Computer User Section to the Fisheries Information and Technology Section,
- Clarifying the procedures for new initiatives and topic-oriented meeting proposals,
- Approving the Society's 2009 budget,
- Approving the instream flow resolution for a membership vote,
- Requesting a potential policy statement on the effects of lead from fishing tackle on the environment,
- Adding non-peer-reviewed materials such as front pieces from AFS journals and *Fisheries* to the Fisheries Infobase, and
- Reformulating the division of net proceeds of Annual Meetings to give a larger share to the hosting Chapter.



PHOTOS BY BETH BEARD



Barb Knuth

William Gilly

Jake Rice

Sally Guynn

PHOTOS BY GARRY WISE, OMNR

Saturday also brought the start of several exceptionally popular continuing education workshops, which continued into Sunday and generally were quite full. On Sunday evening the meeting officially kicked off with the Welcome Social at the Congress Center, featuring indoor and outdoor buffets with gourmet local dishes, a blues singer, and memorable views of the nighttime Ottawa skyline.

The Plenary Session on Monday morning featured several major Society awards, which will be highlighted in the October issue of *Fisheries*. The first scheduled speaker, William Gilly of Stanford University, was unable to attend, but Past President Barb Knuth smoothly stepped in and gave his presentation on changes in the Gulf of California since the publication of Hemingway's *Sea of Cortez*. Gilly led a 2004 expedition that retraced Hemingway's 1940 route and he theorizes that the hypoxic zone that has developed in the gulf due to agricultural and tourism development has changed the distribution of pelagic predators. Yellowfin tuna have largely been supplanted by low-oxygen tolerant Humboldt squid, which were not even recorded on Hemingway's expedition. As the Pacific mid-water hypoxic zone has expanded, so has the squid's range expanded as well.

Jake Rice of the Department of Fisheries and Oceans Canada gave the next talk on "Science Advice in a Time of Flux." As classic fisheries management has evolved into more complex precautionary and ecosystem-based approaches, scientific advice to policymakers has also become more complex, with more opportunities for criticism and "strategic misunderstanding." Are the expectations for scientific advice too high to meet and does it even affect decision-making anyway? A retrospective examination of scientific advice regarding Atlantic cod stocks showed that the advice was correct two-thirds of the time and when it was wrong it was usually not conservative enough. Rice suggested that economic incentives like rights-based fishing and eco-certification can help, allowing the heeding of scientific advice to come with both economic and ecological benefits. Biological scientists need to understand these economic instruments and package them with ecological advice by partnering with social scientists.

Finally, Sally Guynn of the Association of Fish and Wildlife Agencies gave a rousing presentation simply titled "Taking the Lead." In it, she took apart several myths about leadership—that people are born leaders, the frequent confusion between leadership and authority, and that leadership comes from a lack of weaknesses rather than a few profound strengths. In managing organizations, leaders must build trust while lowering stress through providing security and invest in taking their mid-level staff from good to great leaders. Courage develops through use, and like other emotions can be triggered by stories that connect with listeners.

PHOTOS BY BETH BEARD

The first of 36 symposia and the contributed paper sessions began after the Plenary Session, including symposia on fish evolving from fisheries pressures, fisheries governance, tagging use in stock assessment, Atlantic salmon restoration, success stories in controlling aquatic invasives, bycatch reduction, stream conservation and recovery, and a special symposium for the candidates for the best student paper award. The Trade Show and Poster Session also began on Monday, with a record number of exhibitors and a new feature called the Lunchbox Film Festival.

The packed Trade Show Social on Monday evening featured a demonstration by the Ministry of Natural Resources Canine Enforcement Unit, along with a colorful character called Magoo the roving busker.

Some sessions on Monday continued on Tuesday, but symposia starting on Tuesday included the community ecology of stream fishes, hydropower and sustainable fisheries, lake trout, freshwater fishes of Canada, highly migratory large pelagics, and squaloid sharks. Meanwhile, the first of the well-attended speed presentations began with a session on standard methods for sampling North American freshwater fish.

PHOTOS BY BETH BEARD AND GARRY WISE, OMNR

A host of activities kept students busy on Tuesday, including the Student-Mentor Lunch, Student Colloquium, Career Fair, and a high-energy Student Social that carried on late into the night at the Honest Lawyer, a Byward Market pub. More than 400 students attended the meeting.

Several awards were presented at the AFS Business Meeting, which will be covered in the October issue of *Fisheries*. The meeting also included a report on AFS finances, an announcement from the Ballot Tally Committee that Bill Fisher had been elected as second vice president, and the approval of the constitutional changes earlier approved by the Governing Board. The instream flow resolution was passed (which will be published in the November issue of *Fisheries*) along with a resolution of appreciation to the Ottawa hosting committee.

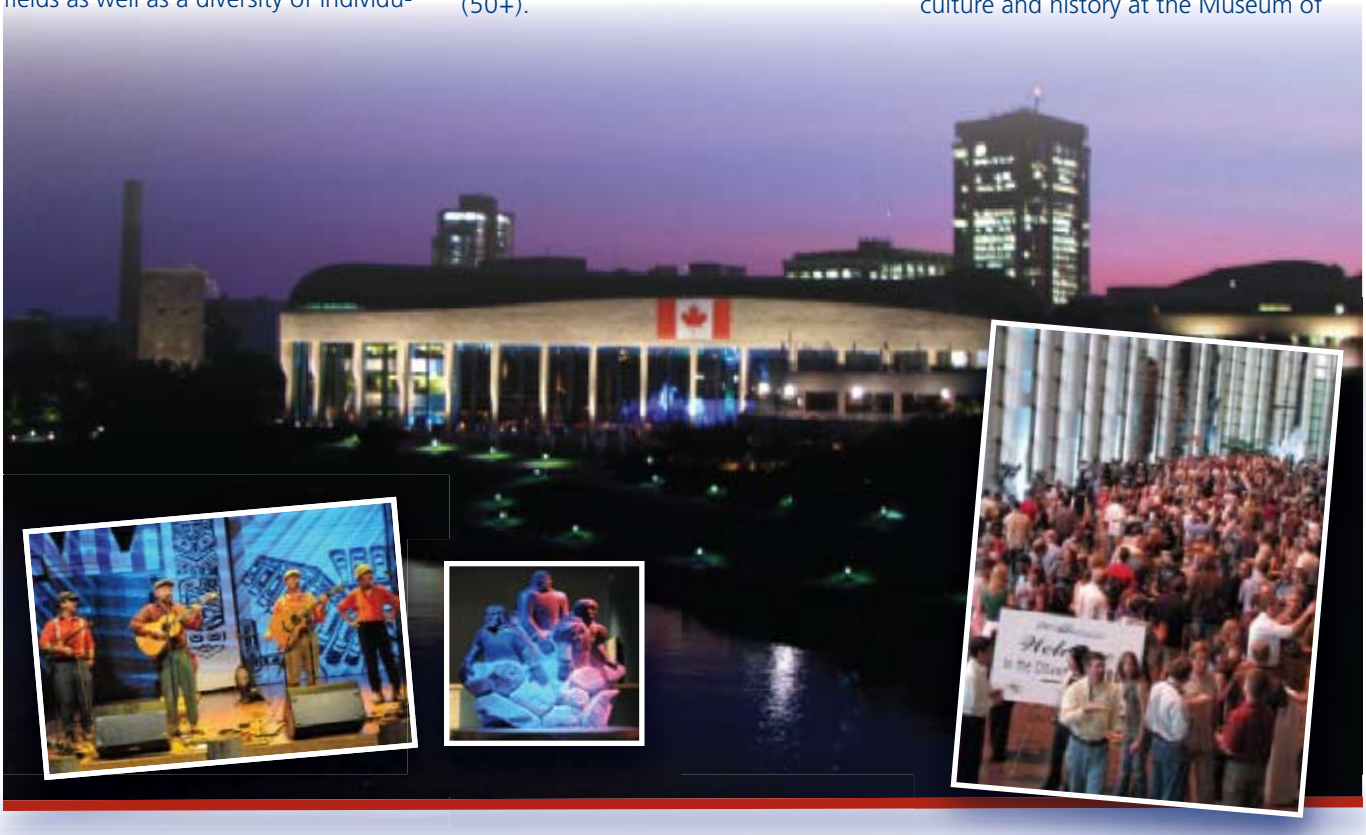
PHOTOS BY GARRY WISE, OMNR

Mary Fabrizio turned over the president's gavel to Bill Franzin, whose theme for the coming year is "Diversity: The Foundation of Fisheries and of AFS—Are we gaining ground?" Franzin explained that it has been 10 years since AFS examined diversity, and although the Society has come a long way, more work is needed to ensure that a diversity of fields as well as a diversity of individuals are represented. The revision of the strategic plan to include more diversity will be a major focus, with the increasingly younger membership of the Society being an important first step.

The next day dawned bright and early for this year's 5-k Spawning Run participants gathered at Dow's Lake. Nicole Porfley and Martin Hamel were the first women's and men's finishers, respectively, in the Young-of-the-Year division (0–29), while Jennifer Eichelberger and Raymond Webster led the Kelts (30–39), Lisa Thompson and Bjarte Bogstad won in the Spawner division (40-49), and Constance Duling and Greg Deyne took first among the Mossbacks (50+).

Wednesday's symposia included sessions on sustainable sturgeon, model selection in fisheries science, aquatic habitat in Midwestern lakes, aboriginial communities in fisheries management, distributed data, viral hemorrhagic septicemia (VHS) in the Great Lakes, cultured aquatic animals, fisheries management for ecosystem health, fisheries certification, well-managed fisheries, climate-related drying effects, parental effects in recruitment, and social and economic science in fisheries management, along with a speed presentation session on aquatic habitat restoration on the Toronto waterfront.

The Wednesday night social proved to be as big as all Canada, as attendees enjoyed the breadth of Canadian culture and history at the Museum of



PHOTOS BY BETH BEARD AND GARRY WISE, OMNR

Civilization. Food and beverage stations scattered through the museum encouraged exploration while the main hall and its totem poles provided a spectacular backdrop for logging camp music of the colorful Wakami Wailers.

Attendance remained strong at Thursday's symposia, with topics including the sensitivity of fish and fisheries to climate change, genetics and sustainable fisheries, fish habitat, Great Lakes native species restoration, sampling for understanding headwater streams and fish production, barotrauma in fish, and harvest control rules. The meeting wrapped with a last chance to catch up with colleagues at the Farewell to Ottawa—Welcome to Nashville social.

Centrally located, Nashville is an affordable destination within 650 miles of 50% of the U.S. population. Local attractions include Nashville's famous country music scene, as well as battlefields, world class fishing, distillery tours, and museums. The hotel and convention center will offer space for up to 30 concurrent sessions. As AFS looks forward to visiting the world's country music capital, the engaging program, warm hospitality, and spectacular sights of Canada's capital of Ottawa provided for an AFS meeting that won't be soon forgotten. ⚓

For more photos of the Annual Meeting, see www.fisheries.org

PHOTOS BY GARRY WISE, OMNR

COLUMN:
STUDENTS' ANGLE

Connecting with the Community through Active Pond Management

Quinton E. Phelps and Nicholas C. Wahl

Phelps is a Ph.D. student in the Fisheries and Illinois Aquaculture Center at Southern Illinois University—Carbondale, and serves as SIUC-AFS Student Subunit president and Southern Division representative to the Student Subsection of the Education Section. Wahl is an M.S. student in the Fisheries and Illinois Aquaculture Center at SIUC, and serves as SIUC-AFS Student Subunit past president.

Within many college towns, there exists a minor disconnection between university departments and the surrounding community. Local residents often do not have a clear idea of the many resources available to them within the halls of academia residing literally down the street. Southern Illinois University in Carbondale is no different. It is a moderately large, research-active university in a small town within a rural region, that contains the Fisheries and Illinois Aquaculture Center (FIAC). The faculty, students, and staff of the FIAC take pride in our research, courses, and outreach. Through our Student Subunit of the American Fisheries Society, we have attempted to serve the local community in southern Illinois in many ways, such as aiding the Illinois Department of Natural Resources with the Urban

Graduate students Quinton Phelps (center), Adam Lohmeyer (left) and Nicholas Wahl (right) from Southern Illinois University collect data from a small impoundment.

Fishing Program, implementing fishing derbies on campus, assisting the local science center, and presenting fisheries information at the state fair. Although these outreach programs have been successful, we still believe that the local community is largely unaware of what we do in the FIAC and its associated Student Subunit. In response, members of our Subunit spent several meetings brainstorming about specific projects that would better advertise our unique assets and potential service to southern Illinois. After much deliberation, we decided to provide pond assessments and management advice to provide outreach to the community. Several individuals, including administrators, faculty, and students within the FIAC, supported the program and were excited to watch it prosper.

Obviously, in our zeal to provide outreach to the community we have to avoid stepping on toes. For example, some businesses provide pond management advice; we certainly do not want to negatively affect the livelihoods of others. The Illinois Department of Natural Resources—like many state agencies—provides pond management advice (IDNR 2001), but resources (time, money, and people) are limited. However, the IDNR biologists will provide expertise and equipment as needed and are more than happy to educate and network with students in the program. Keeping all the constituent groups in mind, we describe the primary benefits of providing a pond management program through the FIAC and its Student Subunit.

GETTING STARTED

We view our participation in a pond management outreach program as complementary to other efforts to manage private ponds in southern Illinois. We are capable of performing these tasks, as we have easy access to fisheries sampling equipment and ample pond management knowledge. Furthermore, this program would provide further connections with local agency biologists who simply do not have the time and resources to provide these services to the region. This is only one of the many potential benefits of a local pond management outreach program operating out of a university fisheries program.

The program to date involves a local resident contacting us (via word of mouth or our pond management website) and requesting an assessment. We (i.e., several Subunit members who have volunteered their time) sample the resident's impoundment (which generally only takes an afternoon/evening of sampling) and then provide them with a detailed management plan that allows them to manage their pond for their specific objectives. Our client also receives a brief education on the life histories of the fish that live in their pond as well as intra and inter-specific interactions that may be occurring (see excerpt from management plan below). By taking an ecosystem/watershed approach, the pond owner also receives education on watershed management (i.e., reducing nutrient inputs via storm-water runoff, septic runoff, etc.). Beyond the basic learning and management plan, the pond owner has obtained a contact within the local university to whom they can go for any necessary pond management assistance or any other fisheries advice

in the future. As they say, it is not what you know, but who you know.

BENEFITS OF A POND MANAGEMENT PROGRAM

From an education perspective, both graduate and undergraduate students obtain hands-on experience (i.e., active learning) in sampling small impoundments, evaluating data, and developing a management plan. All too often we fail to realize that the time spent in a classroom learning the theoretical portion (i.e., visual learning) of fisheries management does not always carry over to real-world experiences. For example, we learn about predator-prey interactions in the classroom, tipping our hats to Homer Swingle (e.g., Swingle 1950) and Richard Anderson (e.g., Anderson 1976), but to really understand the effects of an imbalanced predator-prey relation, a student needs to put his or her hands on a pile of small bluegill and a few huge largemouth bass in a small pond. Studying ponds is like using an aquarium to study fish community interactions. As students become more familiar with the relationships in small ponds, they develop a solid foundation for becoming fisheries biologists/ecologists working in much larger and more complex systems.

From a human dimensions perspective, students gain real-world experience with the public. As we all know, in most fisheries-related careers, public relations can be the most time-consuming part of the job (90% people management and 10% resource management). It is also important to let the public know that they have a group of skilled and knowledgeable folks in fisheries at their disposal, ultimately bridging the gap between the community and our program in the FIAC. Conducting community outreach through a pond management program has many more benefits, including the satisfaction of providing a service on behalf of the American Fisheries Society.

Although our Subunit in the FIAC has only been performing pond management outreach for a little over a year, we believe that it has been beneficial to the southern Illinois community. Before the onset of our "official" program, pond owners would contact the FIAC for pond assistance and information and we would supply management recommendations. Since that time, we have branched out and now provide assistance to those who contact our program via word-of-mouth and have also added a link on the FIAC's web page to assist pond owners (fisheries.siu.edu/afs/pondmanagement.html). An excerpt from our web site reads as such:

> *Here at Southern Illinois University, we pride ourselves on being a great fisheries university. Most students involved with the Fisheries and Illinois Aquaculture Center have received substantial education in fisheries management. Thus, the Student Subunit of the American Fisheries Society provides guidance on pond/small impoundment management to the southern Illinois public. We have fisheries equipment that allows us to determine the current status of fish communities in these small water bodies. We would be glad to come out to any pond in the southern Illinois area and provide management recommendations. We are a non-profit organization; thus, all pond management work will be completed free of charge. However, if pond owners deem compensation appropriate, donations will be accepted. All donations will be used to allow students to attend professional fisheries meetings, to maintain fisheries equipment, and to ameliorate the travel costs for pond sampling. Please contact us if you have any questions or would like for us to come out and investigate your pond.*

This advertisement provides groundwork for individuals seeking pond management advice. It should be noted, however, that because of time limitations and to prevent any conflict with private consultants, we have put a limit on the number of ponds that we will manage each year. We decided that about six ponds per year is our limit because although outreach is important, we also have many other responsibilities as part of our educational program. Student Subunits must choose enough ponds to provide a service to the community while maintaining high quality management plans.

As stated above we provide management plans to individual pond owners. The management plans are simple and provide the landowner an understanding of pond management. Usually, we devise our management plans as a typical report with Introduction, Methods, Results, and Summary sections. By formatting each management plan in this manner, it allows anyone who performs a later consultation on the same pond to see detailed information about past findings. In the Introduction, we provide an overview to pond management and life history information of fishes that reside in ponds. The methods section provides written documentation that describes the procedures used to capture fishes and analyze data. Within the results section we provide a species-by-species overview (catch rates, size structure, age, growth, etc.), and then discuss interactions among species present. In the Summary section of the management plan, we describe the current status of the pond and make explicit management recommendations for the pond owner. Box 1 contains an example summary of one of our pond management plans.

Box 1
Example Summary Management Plan

We collected panfishes (i.e., bluegill, redear, and black crappie), largemouth bass, and channel catfish on November 9th and 10th, 2006 from Doe Lake. Results of the Doe Lake survey indicated that the channel catfish population should remain at current sizes and number; however, there is an overpopulated panfish community (i.e., overly abundant, slow growing, and small individuals) that are being ineffectively controlled by the few big largemouth bass present. Because Mr. (or Ms.) Doe would like to catch large panfish, we recommend stocking additional predators (i.e., largemouth bass) to increase predation on the abundant panfish. After the proper stocking protocol for predators is employed (75 six- to eight-inch largemouth bass per acre for 3–5 years as per Illinois Department of Natural Resources recommendations), the numerous small panfish will become less abundant through increased predation by the higher abundance of predators. We recommend a 15-inch minimum length limit on the largemouth bass to prevent overharvest and ensure that sufficient bass are present to prey upon the panfish species. As a result, the size of panfish will increase and satisfy the objectives for the pond. Future lake surveys will need to be conducted to ensure that the management strategy and stocking protocol were adequate to maintain these objectives.

CONCLUSION

As noted above, the management plans are simple, straightforward, and provide easy-to-follow information to the pond owner. Although our program is still young, we believe that we are providing an important and useful service to the southern Illinois community. Overall, we hope that other institutions with fisheries programs and Student Subunits will develop a pond management program (or stream management program), following a framework similar to the one we have described. A pond management program is a win-win strategy. Ultimately, fisheries education and outreach is a grass-roots, local effort and, in our view, this is a great way to achieve this goal. ⚓

ACKNOWLEDGEMENTS

We would like to thank Melissa Wuellner, James Garvey, and David Willis who reviewed and greatly improved a prior version of this manuscript. We would also like to thank the members of the SIUC student subunit and several southern Illinois pond owners who made this pond management program possible.

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CALENDAR: FISHERIES EVENTS

More events listed at www.fisheries.org click "Who We Are" click "Calendar"

DATE	EVENT NAME CITY, STATE	FOR MORE INFORMATION
Oct 11-15	**Fourth National Conference on Coastal and Estuarine Habitat Restoration** Providence, Rhode Island	www.estuaries.org/?id=4
Oct 12-15	**62nd Annual Southeastern Association of Fish and Wildlife Agencies Conference** Corpus Christi, Texas	http://seafwa2008.org
Oct 17-21	**Aquatic Resources Education Association Conference** Corpus Christi, Texas	www. areanet.org
Oct 19-22	**Women Evolving Biological Sciences** Seattle, Washington	www.webs.washington.edu
Oct 19-24	**International Aquarium Congress 2008** Shanghai, China	www.iac2008.cn
Oct 20-24	**Fifth World Fisheries Congress 2008** Pacifico Yokohama, Japan	www.5thwfc2008.com, wfc2008@ics-inc.co.jp, +81-3-3219-3541
Oct 22-23	**State of the Lakes Ecosystem Conference** Niagara Falls, Ontario, Canada	solec@ec.gc.ca
Oct 22-24	**Offshore Mariculture 2008** Alicante, Spain	www.offshoremariculture.com
Oct 23-25	**First Annual Western Division of the American Fisheries Society Student Colloquium** Bozeman, Montana	www.montana.edu/msuafs/Documents/2008_WDAFS_STUDENT_COLLOQUIUM.pdf
Oct 28-29	**Coastal Research Symposium** Biloxi, Mississippi	http://masgc.org
Nov 2-7	**Seventh International Flatfish Symposium: The Impact of Environmental Changes on Flatfish Productivity** Sesimbra, Portugal	www.flatfish2008.fc.ul.pt
Nov 7-8	**Eighth Annual AFS Student Colloquium** Pikeville, Tennessee	http://orgs.thtech.edu/sfa
Nov 9-13	**Integrating Biogeochemistry and Ecosystems in a Changing Ocean: Ecological and Biogeochemical Interactions in End to End Food Webs Workshop** Miami, Florida	www.confmanager.com/main.cfm?cid=1185
Nov 10-13	**Fifth World Recreational Fishing Conference** Dania Beach, Florida	www.igfa.org, 954/927-2628.
Nov 11-14	**North American Lake Management Society Symposium** Lake Louise, Alberta, Canada	www.nalms.org
Nov 14-16	**Third International Bonefish and Tarpon Symposium: Research and Conservation for the Future** Dania Beach and Islamorada, Florida	aadams@mote.org
Nov 19-22	**11th International Conference on Shellfish Restoration** Charleston, South Carolina	www.scseagrant.org/Content/?cid=297
Nov 21-22	**AquaMedit 2008: Using Technology in Aquaculture and Fisheries to Produce Safe Food for the Consumers** Athens, Greece	http://connect.to/pasti
Nov 23-25	**International Symposium on the Bearing-Aleutian Salmon International Surveys: Climate Change, Production Trends, and Carrying Capacity of Pacific Salmon in the Bering Sea and Adjacent Waters** Seattle, Washington	www.napafc.org
Dec 2-4	**Western States Tourism Policy Council Gateway Conference—Gateway Today: Balancing Conservation and Community in an Age of Diversity, Change, and Challenge** Albuquerque, New Mexico	www.newmexico.org/WSTPC
Dec 3-4	**11th Flatfish Biology Conference** Westbrook, Connecticut	http://mi.nefsc.noaa.gov/flatfishbiologyworkshop, rmercald@clam.mi.nmfs.gov, 203/882-6549
Dec 14-17	**Midwest Fish and Wildlife Conference** Columbus, Ohio	www.2008MWFWC.com

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

2009

Jan 13-14		**Lake Mead Science Symposium**	
		Las Vegas, Nevada	www.lakemeadsymposium.org
Jan 15-18	AFS	**Spring Meeting of the Southern Division and Louisiana Chapter of the AFS**	
		New Orleans, Louisiana	www.sdafs.org/meetings
Jan 22-23		**Great Lakes Urban Habitat Restoration Symposium**	
		Chicago, Illinois	www.glfc.org/urbanrestore
Jan 27-31	AFS	**Texas Chapter of AFS and Texas Parks and Wildlife Department—Fisheries and Harmful Algae: Can They Co-Exist?**	
		Fort Worth, Texas	Fred.Janssen@tpwd.state.tx.us
Feb 2-5		**State of the Salmon**	
		Vancouver, British Columbia, Canada	www.stateof the salmon.org/conference2009
Feb 15-18		**Aquaculture America 2009**	
		Seattle, Washington	www.was.org
Mar 30-Apr 3		**Improving the Ecological Status of Fish Communities in Inland Waters: International Symposium and EFI+ Workshop,**	
		Hull, United Kingdom	www.hull.ac.uk/hifi/events/index.html
May 3-7	AFS	**Western Division Annual Meeting—Evolution of the Western Landscape: Balancing Habitat, Land, and Water Management for Fish**	
		Albuquerque, New Mexico	www.aznmfishsoup.org/wdafs09/index.htm
May 22-26		**Third and Last GLOBEC Open Science Meeting**	
		Victoria, British Columbia, Canada	www.globec.org
May 25-29		**World Aquaculture 2009**	
		Veracruz, Mexico	www.was.org
Jun 1-11		**Indo Pacific Fish Conference and Australian Society for Fish Biology**	
		Fremantle, Western Australia	www.asfb.org.au/events
Jun 14-19		**Seventh International Conference on Molluscan Shellfish Safety**	
		Nantes, France	www.icmss09.com
Jun 23-26		**International Paleolimnology Symposium**	
		Guadalajara, Jalisco, Mexico	www.paleolim.org
Aug 14-17		**Aquaculture Europe 2009**	
		Trondheim, Norway	www.easonline.org
Aug 30-Sep 3	AFS	**American Fisheries Society 139th Annual Meeting**	
		Nashville, Tennessee	www.fisheries.org ⚓

NASHVILLE

1st CALL FOR PAPERS

AMERICAN FISHERIES SOCIETY

2009

THE TENNESSEE CHAPTER

of the American Fisheries Society and the Tennessee Wildlife Resources Agency will host the 139th Annual Meeting of the American Fisheries Society in downtown Nashville, Tennessee, 28 August–3 September 2009. The Renaissance Marriott Hotel and adjoining Nashville Convention Center provide a world class venue for this gathering of fisheries students and professionals. The meeting's theme, "Diversity—The Foundation of Fisheries and the AFS: Are we gaining ground?" was established by AFS President Bill Franzin and it is perfectly suited to the meeting site. Nashville is a city that is as diverse in cultures as it is in music and will provide a perfect backdrop for discussions on diversity among fisheries professionals. Also, the Cumberland River flows through downtown Nashville and Tennessee's rivers and streams are home to one of the world's most diverse assemblages of fish, mussels, and macroinvertebrates. From high mountain streams in the east to the Mississippi River in the west, Tennessee is home to more than 300 species of fish, 120 species of mussels, and 77 species of crayfish. What better place is there than Nashville, Tennessee, to talk about fish, fisheries, the habitats that support them, and the people who have devoted their careers to fisheries?

We also encourage everyone to enjoy Nashville and surrounding areas before, during, and after the meeting. Nashville is a popular destination for people interested in Civil War Era history; several plantations, forts and battlefields are located within an hour's drive. But we don't call it The Music City for the history—Nashville's sounds will steal the show. Local musicians like to say "We built this city on rock & roll, R&B, country, bluegrass, gospel, soul, and just about every other kind of music" and meeting attendees interested in exploring music venues throughout the city will find that to be the gospel truth. In fact, one of our socials will be held right across the street from the conference hotel in the historic Ryman Auditorium—the longtime home of the Grand Ole Opry. Attendees will find Nashville easy to get to and find it easy to enjoy what she has to offer, so please check your calendars, dust off your honky-tonkin' clothes, and make plans to join us.

A visit to Nashville is not complete without visiting the Country Music Hall of Fame.

GENERAL INFORMATION

Aquatic resource professionals are invited to submit symposia proposals and abstracts for papers in a range of topics and disciplines. Participation by scientists at all levels and backgrounds, especially students, is encouraged.

The scientific program includes two types of sessions: Symposia (oral and poster presentations that focus on a single topic) and Contributed Papers (oral and poster presentations on any relevant topic).

Oral presentations are limited to 20 minutes (15 minutes for presentation plus 5 minutes for speaker introduction and questions). All oral presenters are expected to deliver PowerPoint presentations. Presenters must bring their PowerPoint file to the meeting on CD or USB flash memory stick by 7 p.m. the evening before their presentation. Laptop computers and LCD projectors will be provided and technicians will be available to help.

Traditionally, symposia have been dominated by oral presentations and sometimes supplemented by posters. The Nashville '09 Program Committee is considering following the example set at the Ottawa '08 meeting and allowing "Speed Presentations" coupled with posters to shorten the time required for symposia. This new format elevates the profile of symposium posters through a "speed presentation subsession" that provides a time slot for short (i.e., 3 minute) oral presentations, followed by dedicated viewing of symposium posters. Look for more details in upcoming Calls for Papers on this exciting new way to transfer information and foster communication among symposia participants.

SYMPOSIUM

The Program Committee invites proposals for symposia. Topics must be of general interest to AFS members. Topics related to the meeting theme will receive priority. Symposium organizers are responsible for recruiting presenters, soliciting their abstracts, and directing them to submit their abstracts through the AFS online abstract submission form. A symposium should include a minimum of 10 presentations and we encourage organizers to limit their requests to one-day symposia (about 20 oral presentations). Regular oral presentations are limited to 20 minutes, but double time slots (i.e., 40 minutes) may be offered to keynote speakers. Symposia with less than 15 or more than 20 presentations are strongly discouraged.

Symposium proposals must be submitted by 9 January 2009 via e-mail to Mark Bevelhimer (bevelhimerms@ornl.gov) with the proposal attached in the correct format in MS Word or WordPerfect; please contact Mark Bevelhimer if you do not receive confirmation by January 16. The Program Committee will review all symposium proposals and notify organizers of acceptance or refusal by 6 February 2009. If accepted, organizers must submit a complete list of all confirmed presentations and titles by 27 February 2009. Symposium abstracts (in the same format as contributed abstracts; see next page) are due by 6 March 2009.

FORMAT FOR SYMPOSIUM PROPOSALS

1. **Symposium title:** Brief but descriptive
2. **Organizer(s):** Provide name, address, telephone number, fax number, and e-mail address of each organizer. Indicate by an asterisk the name of the main contact person.
3. **Description:** In 300 words or less, describe the topic addressed by the proposed symposium, the objective of the symposium, and the value of the symposium to AFS members and participants.
4. **Format and time requirement:** Indicate the mix of formats you are considering (oral, speed presentation, poster). State the time required for regular oral presentations (i.e., 20 minutes per speaker) and the time required for speed presentations (if any) and poster viewing (3 minutes per speaker plus time for poster viewing).
5. **Chairs:** Supply name(s) of individual(s) who will chair the symposium.
6. **Presentation requirements:** We encourage speakers to use PowerPoint for presentations. All Mac-based presentations must be converted to PC format prior to the meeting. Presentations in other software programs must be approved prior to acceptance.
7. **Audiovisual requirements:** LCD projectors and laptops will be available in every room. Other audiovisual equipment needed for the symposium will be considered, but computer projection is strongly encouraged.
8. **Special seating requests:** Standard rooms will be arranged theatre-style. Please indicate special seating requests (for example, "after the break, a panel discussion with seating for 10 panel members will be needed").
9. **List of presentations:**
   Please supply information in the following format:

Presenter's name	1. _____
	2. _____
Tentative title of presentation	1. _____
	2. _____
Confirmed (yes/no)	1. _____
	2. _____
Presentation format (regular or speed)	1. _____
	2. _____

10. **Sponsors:** If applicable, indicate sponsorship. Please note that a sponsor is not required.

Conference attendees will gather for a fun night of lively music at the historic Ryman Auditorium—the longtime home of the Grand Ole Opry.

CONTRACTS

General Meeting Chair

Bobby Wilson
Tennessee Wildlife Resources Agency
Bobby.Wilson@state.tn.us
615/781-6578

Local Arrangements Chair

Dave Rizzuto
Tennessee Wildlife Resources Agency
David.Rizzuto@state.tn.us
731/225-4422

Tim Churchill
Tennessee Wildlife Resources Agency
Tim.Churchill@state.tn.us
931/781-6645

CONTRIBUTED ORAL AND POSTER PAPERS

The program committee invites abstracts for presentations (oral and poster) at contributed paper sessions. Authors must indicate their preferred presentation format: (1) oral only, (2) poster only, (3) oral preferred, but poster acceptable. Only one oral presentation will be accepted for each senior author. Poster submissions are encouraged because of the limited time available for oral presentations. The program will include a dedicated poster session to encourage discussion between poster authors and attendees.

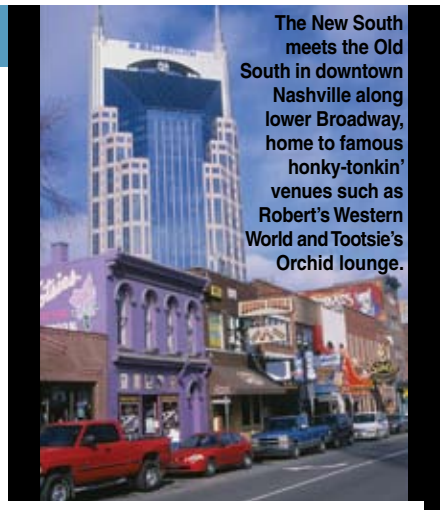
Abstracts for contributed oral and poster papers must be received by 6 February 2009. All submissions must be made using the AFS online abstract submission form, which is available on the AFS website (www.fisheries.org). When submitting your abstract:

- Use a brief but descriptive title, avoiding acronyms or scientific names in the title unless the common name is not widely known;
- List all authors, their affiliations, addresses, telephone numbers, and e-mail addresses;
- Provide a summary of your findings and restrict your abstract to 200 words.

All presenters will receive a prompt e-mail confirmation of their abstract submission and will be notified of acceptance and the designated time and place of their presentation by 30 April 2009.

For contributed papers, you will have the opportunity during the abstract submission process to indicate which two general topics best fit the concept of your abstract. Topics include: Bioengineering, Communities and Ecosystems, Contaminants and Toxicology, Education, Fish Culture, Fish Health, Fish Conservation, Freshwater Fish Ecology, Freshwater Fisheries Management, Genetics, Habitat and Water Quality, Human Dimensions, Marine Fish Ecology, Marine Fisheries Management, Native Fishes, Physiology, Policy, Population Dynamics, Statistics and Modeling, Species Specific (specify) and Other (specify). Including this information in your submission will help the Program Committee assign your talk, if accepted, to the most appropriate session.

Late submissions will not be accepted. AFS does not waive registration fees for presenters at symposia, workshops, or contributed paper sessions. All presenters and meeting attendees must pay registration fees. Registration forms will be available on the AFS website (www.fisheries.org) in May 2009; register early for cost savings.



The New South meets the Old South in downtown Nashville along lower Broadway, home to famous honky-tonkin' venues such as Robert's Western World and Tootsie's Orchid lounge.

FORMAT FOR SUBMITTED ABSTRACTS

For abstracts submitted to a Symposium:
Enter Symposium title: _____
Specify format: 1. Oral
2. Speed presentation (accompanied by poster)

For abstracts submitted as a Contributed Paper:
Enter 2 choices for topic: _____
_____
Specify format: 1. Oral
2. Poster
3. Oral preferred, but poster acceptable

For all abstracts:
Title: An example abstract for the AFS 2009 Annual Meeting
Authors:
Bettoli, Phillip. Tennessee Cooperative Fishery Research Unit, 205 Pennebaker Hall, Tennessee Tech University, Cookeville, Tennessee 38505; 931/372-3086; pbettoli@tntech.edu
Bevelhimer, Mark. Environmental Sciences Division—ORNL, BLDG 1505, P.O. Box 2008, Oak Ridge, Tennessee 37831; 865/576-0266; bevelhimerms@ornl.gov
Fiss, Frank. Tennessee Wildlife Resources Agency, P.O. Box 40747, Nashville, Tennessee 37204; 615/781-6519; Frank.Fiss@state.tn.us
Presenter: Phillip Bettoli
Abstract: Abstracts are used by the Program Committee to evaluate and select papers for inclusion in the scientific and technical sessions of the 2009 AFS Annual Meeting. An informative abstract contains a statement of the problem and its significance, study objectives, principal findings and application, and it conforms to the prescribed format.
Student presenter? (Work being reported was completed while a student): No

Contributed Papers Chair

Phil Bettoli
U.S. Geological Survey/ Tennessee Cooperative Fishery Research Unit
pbettoli@tntech.edu
931/372-3086

Symposia Chair

Mark Bevelhimer
Oak Ridge National Laboratory
bevelhimerms@ornl.gov
865/576-0266

Posters Chair

Frank Fiss
Tennessee Wildlife Resources Agency
Frank.Fiss@state.tn.us
615/781-6519

Organizing a continuing education course or workshop?

Please check future Calls for Papers for information on who to contact. If you seek immediate assistance, please contact Contributed Papers Chair Phil Bettoli.

Continued from page 432

CHESAPEAKE BAY OYSTER RESTORATION HEARING

On 10 September 2008, the House Subcommittee on Fisheries, Wildlife, and Oceans held a hearing focusing on H.R.6479 and restoration of the Chesapeake Bay oyster. The hearing included Denise Breitburg of the Smithsonian Environmental Research Center who stated that she believed the impediments that have been most critical in limiting the success of the oyster restoration effort to date are:

- The scale of the efforts of the problem;
- Limited emphasis on research and restoration designed specifically to learn how to restore oysters;
- Use of suboptimal sites for restoration; and
- The variety of environmental technical hurdles that need to be overcome.

William Goldsborough of the Chesapeake Bay Foundation stated poor water quality and sedimentation are key habitat limitations for oysters and will hamper restoration if they are not addressed. He further stated that economic and ecological objectives in oyster restoration (including funding streams, implementation, and monitoring) should be separated. He concluded by stating that the development of commercial aquaculture in the Chesapeake Bay, with particular attention to limiting factors such as hatchery capacity, availability of suitable grounds, and historical impediments, should be encouraged.

Col. Dionysios Anninos of the U.S. Army Corp of Engineers stated that the ongoing oyster programmatic environmental impact statement and the follow-on native oyster master plan should be used as the driver and the foundation documents to execute a comprehensive oyster program and economic program. He also stated that economic and ecological oyster restoration should be considered as separate entities and success for each measured differently. He concluded by commenting that future short and long-term restoration and support to industry goals and objectives should be realistic and obtainable.

Peyton Robertson of the National Oceanic and Atmospheric Administration (NOAA) stated that large-scale oyster restoration in the Chesapeake Bay is contingent on having large quantities of oysters for restoration and adequate infrastructure to move and place seed in the bay. He also stated that oyster restoration requires adaptive management, where sufficient flexibility is needed to alter approaches and to refine efforts based on thoughtful monitoring, analysis, and evaluation results. He concluded his statement by stating that NOAA believes that targeted, scientifically-sound, and cost-effective restoration is important. This is particularly true in the protection and improvement of fully functioning habitats, which are paramount to the overall effort to restore the bay. ⚓

ANNOUNCEMENTS: JOB CENTER

* EMPLOYERS: The AFS Online Job Board lists job announcements at $350 per 150-word increments. Submit a position description, job title, agency/company, city, state, responsibilities, qualifications, salary, closing date, contact information, and billing information to jobs@fisheries.org.
* AFS MEMBERS: Organizations with Associate, Official, and Sustaining memberships, and individual members who are faculty members seeking graduate assistants can submit listings with a 150-word maximum at no charge.

(If space is available, some jobs may be selected from the AFS Job Board to be printed in *Fisheries* magazine, free of additional charge.)

To see more job listings go to www.fisheries.org and click Jobs.

Natural Resources Biologist I, Maryland Department of Natural Resources Fisheries Service, Annapolis.

Responsibilities: Provide technical and administrative support to Maryland's striped bass harvest monitoring program. Assist the current biologist in net inspections and certifications, tag distribution, and data management. Assist with the distribution and collection of harvest permit cards and declarations of intent.

Qualifications: B.S. from an accredited college or university in biology, natural science, natural resources management, botany, marine biology, fisheries management, zoology, or a natural resources management related field of study. Preference will be given to candidates who have up to one year experience working with Microsoft Access.

Closing date: 26 October 2008.

Salary: $31,461–$40,441 contractual. No benefits.

Contact: See www.dnr.state.md.us/hr/jobs.asp for more information about the position and the application process.

Fisheries Biologist I, Arkansas Game and Fish Commission, Fisheries Division, Mammoth Spring.

Responsibilities: Assist with all duties associated with a coldwater intensive culture trout hatchery including: spawning fish, monitoring development of eggs and fry, developing and implementing feeding schedules, administering chemical treatments for disease, monitoring water quality, maintaining hatchery production records, collecting and entering data, preparing reports on hatchery operations, assisting in the supervision of the hatchery staff, training workers in fish husbandry techniques, and assisting other personnel as needed with sampling and habitat improvement work.

Qualifications: B.S. in biology, zoology, botany, or a related field, or equivalent.

Salary: Grade 18, $26,415 per year. Salary above $26,415 requires exceptional qualifications as determined by the Office of Personnel Management.

Closing date: 26 October 2007.

Contact: See www.agfc.com/employment/. For additional information contact Melissa Jones, 877/625-7521.

Marine Stewardship Council (MSC) Chain of Custody Auditor, MRAG Americas, throughout North America, with emphasis on the U.S., particularly the West Coast, and Canada.

Responsibilities: Perform Chain of Custody Certifications on an as-needed, contractual basis and write audit reports for seafood processors, distributors, retailers, and restaurants against the MSC Standard. Travel required.

Qualifications: B.S. or higher. QMS, ISO, HACCP, or similar experience. Fisheries experience preferred. Auditor training on the MSC Standard provided.

Salary: Paid an agreed upon daily rate consistent with qualifications and the location of the work. 10–20 days of work per year per auditor.

Closing date: 28 October 2008.

Contact: E-mail CV and cover letter to Jennie Harrington, jennie.harrington@mragamericas.com. See www.mragamericas.com.

Graduate Research Assistant—M.S. or Ph.D Students (2 positions), Department of Fisheries and Wildlife, Michigan State University, East Lansing.

Responsibilities: Collaborate in project investigating the effects of spring fishing and residential shoreline development on the nesting dynamics of black bass in Michigan lakes. Integrate field observations of nesting black bass with application of genetic techniques multi-locus genotyping methods to investigate the contribution of individual black bass nests to year class strength. Work closely with Michigan Department of Natural Resources Fisheries Division personnel.

Qualifications: Field experience in aquatic systems, desire to integrate fundamental ecology research with fisheries management application, familiarity with conservation genetics techniques, and experience with behavioral observations of fishes.

Salary: $1,750 per month plus tuition, fees, and student health benefits. Possible paid teaching assistantships or fellowships.

Start date: Starting date is negotiable within the range January–May 2009. Field work for the project begins in May 2009.

Deadline: Early December 2008.

Contact: Send CV, statement of career objectives, unofficial transcripts, GRE scores, and names and phone numbers of three references to Mary Bremigan, Department of Fisheries and Wildlife, 13 Natural Resources Building, East Lansing, Michigan 48824; bremigan@msu.edu; 517/432-3831.

M.S. Graduate Research Assistantship, Fisheries and Illinois Aquaculture Center, Department of Zoology, Southern Illinois University.

Responsibilities: Conduct research using stable isotopes and fatty acids as indicators of nutritional and food web pathways to fishes.

Qualifications: B.S. in fisheries, aquatic biology, or a closely related

field. Meet admission requirements for the graduate school and the university's Department of Zoology. See www.science.siu.edu/zoology/programs-graduate.html. Field experience sampling fishes and strong analytical, quantitative, and communication skills.

Start date: January 2009.

Salary: $17,000 per year plus full tuition waiver and subsidized health insurance.

Contact: Submit a letter of interest, resume, contact information for three references, copies of transcripts, and GRE scores to Greg Whitledge, Fisheries Illinois Aquaculture Center, Southern Illinois University, Carbondale, Illinois 62901-6511; 618/453-6089; www.science.siu.edu/zoology/programs-graduate.html gwhit@siu.edu.

Tenure-track Faculty Member,
Department of Biological Sciences, Lake Superior State University, Sault Sainte Marie, Michigan.

Responsibilities: Half time teach undergraduate classes and laboratories; create innovative instructional materials and laboratory experiences including web-based instruction; establish a record of sustained scholarship; develop sources of external funding for applied research and projects with industry; promote the program through local, regional, and national engagement; participate in program assessment activity related to accreditation; and perform student advising and other departmental service, including internal and University committee work. Half-time oversee the Aquatic Research Laboratory's Fish Health Lab and half-time to teach upper-level undergraduate courses such as virology, ecology of animal disease, animal physiology, and histopathology.

Qualifications: Training in the discipline of fish health with a DVM or Ph.D. in biology or related discipline. Preference will be given to candidates who demonstrate potential for exceptional teaching and expertise in analytical techniques such as QELISA, Q-PCR, and histopathology.

Salary: Commensurate with qualifications and experience.

Deadline: 1 November 2008 or until filled.

Contact: Submit a signed cover letter, CV, statement of teaching philosophy, and names and contact information for three references to Fish Health Search Committee, Human Resources Office, Lake Superior State University, 650 W. Easterday, Sault Sainte Marie, Michigan 49783. Contact Human Resources at 906/635.2213. See www.lssu.edu/biology and www.lssu.edu/arl. EO/AAEmployer.

EGG LAYING FIDELITY

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Researchers approached ATS with a unique project involving egg hatching success and location of horseshoe crabs. Predation, shoreline development and general human presence was suspected of reducing potential reproduction success.

ATS engineers and biologists designed a strategy for this challenging study using long-range transmitters that could be heard up to 7.6 km (4.75 mi.) to the north and south of automated data logging stations.

This study also required that several hundred radio tagged animals be monitored over short time intervals. ATS coded tag technology allows for as many as one hundred tags per frequency. Multiple coded tags on a single frequency can reduce scan time by 50 to 90 percent over standard tags. They also provide much higher data reliability by enhancing signal and noise separation.

This method was highly successful, allowing researchers to track hundreds of subject animals over a large area in short time frames.

As the world leader in the development and manufacture of radio telemetry systems, ATS is proud of the advancements in fish and wildlife research that our products help achieve.

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Investigating Avian Predation of Smolts with New Composite Acoustic Tag

Project Location: Mid-Columbia River Basin, Washington USA


Wanapum Dam on the Columbia River, WA


California Gull

In recent years, avian predation has been suspected as a significant contributor to the loss of juvenile spring salmon along the Columbia River. Because the potential impact to migrating smolt populations is unclear, Grant County PUD (PUD) has implemented a series of programs in an effort to better understand the consumption of migrating salmonids by various bird populations, aimed at reducing predators passing Wanapum and Priest Rapids dams.

Though a number of studies investigating individual bird species have been successful in understanding species' relationship to fish community dymanics, little is known about the birds that inhabit the mid-Columbia during times of salmon smolt out-migration, or how the populations may collectively impact fisheries. The Columbia River Basin (CRB) supports some of the largest populations of piscivorous birds throughout North America and Europe, many of which are colonizing birds, well suited to take advantage of fluctuating fish densities. They include the California Gull, Caspian Tern, and Great Blue Heron.

A variety of methods have been employed to-date to deter bird feeding behavior, e.g. installing wire arrays over powerhouse tailrace areas. And this year, the PUD and HTI put together a new composite acoustic tag to help shed more light on the sources of smolt mortality. The new composite acoustic tag features HTI's *Model 795 Acoustic Tag* embedded with PIT Tag technology. The unique composite tag has two features performing two distinctive functions. HTI's *Model 795 Acoustic Tag* emits sonar 'pings' making it possible to detect 3D movement of fish within the project. This function details vital fish behavior as it migrates. Embedded in the acoustic tag is a second tag, a passive integrated transponder (PIT) tag. It's as small as a grain of rice and it emits no sonar, requiring no battery. It cannot provide fine scale behavior data, however, it can identify throughout the salmon's life, even after the fish has died. This serves the second function, to recognize the presence of a tagged fish at locations along the CRB.

In attempts to better quantify salmonid consumption, PUD biologists will investigate Caspian Tern nesting areas around the Priest Rapids Project in efforts to reveal the impact of the predator/prey dynamic. A direct measurement of bird species abundance and relative distribution as it relates to fisheries management practices can increase our understanding of avian impacts to the restoration efforts of salmon. HTI is pleased to work with Grant County PUD in their commitment to developing protection, mitigation and enhancement programs for fish resources. To learn more about the tools used, call HTI at 206.633.3383.


Caspian Tern


Great Blue Heron

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