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Freshwaters in the Public Eye

The Bait Industry as a Potential Vector for Alien Crayfish Introductions

Maintaining the Competitiveness of the American Fisheries Society Journals

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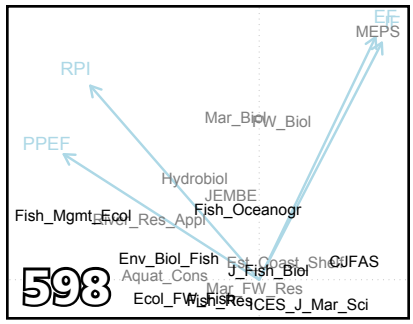
Contents



COVER: A mountain whitefish in Grizzly Creek, Colorado is observed by filmmaker/photographer, Jeremy Monroe.
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Scientific Discipline and Courage

To Be a Dream

What worlds do we form in our dreams?
Perhaps it is fair to wonder, if...
Worlds so made can truly be real
Or if in mind's drifting we're ruled by illusion.

Yet the focus we draw is so clear and intense,
Full of throbbings, life pulse, and good will, so...
The worlds must be real, with visions this sharp.
How tempting to pause and look near.

But in pausing, time stops and the worlds start to fade.
The sun washes out colors, nights soak up the warmth, and...
Hearts pounding, thoughts swirling, we surge forward again,
From the fog, to the beat of some internal drive.

We must move if we're ever to see a dream.
We must move if we're ever to be a dream.
Fading vision if stopped, but so real when we march,
The Dream that We form starts within us.

I wrote this poem (Jackson 1984:152) as a student at Lexington Theological Seminary, in Lexington, Kentucky, many years ago, just after I'd returned from an U.S. Peace Corps assignment in Southeast Asia, and before I returned to science to complete my doctorate in fisheries. It is the poem I shared with you in Nashville, during our Annual Meeting, as I became president of the American Fisheries Society. It is also a poem that kept coming to mind recently during a recent assignment to address an incredibly important fishery issue in California.

On this assignment I found myself thinking long and deep about the role of science in the fisheries professions. I also spent time reflecting on the expression of science, and how it can ultimately become a form of art. Although we may not think about it in this way, we are artists applying the medium of science to landscapes, seascapes, and life processes, and—if we become very still and listen carefully, when our science is very good—we can occasionally hear the rhythms… the music…of the earth. So, in conjunction with sharing the poem with you, I want also to share some of my reflections on the subject of science in fisheries, and give you an example of good scientists at work.

Science requires incredible discipline. When applied to the natural resources fields it tends also to require that its practitioners have considerable courage. On the discipline side we dwell in the realm of null hypotheses, doing whatever it takes to show that a treatment had no effect. Skepticism and rigorous critique are the order of the day. On the courage side, we have visions of how we think things should be and work toward those ends. Energy swells within us and we lean forward, ready to step out into new arenas, new frontiers. Scientific discipline says that we should not step beyond the last point on a regression. Scientific courage dictates that we must take risks, trust the vectors, and move ahead in order to advance the field or address the issue.

The resulting tension is the source of inspiration and creativity that defines careers. It keeps us moving, doing, believing. It simultaneously affirms linear as well as ethereal thought processes and in so doing reassures us that what we do, and how we do it, really matters. If this were not the case our professional lives would be pointless.

An example of this tension, and its power, occurred recently during a meeting of a work group convened by the National Marine Fisheries Service's (NMFS) Southwest Fisheries Science Center in Santa Cruz, California. This work group is charged with assessment of different scenarios for mass marking hatchery-produced fall-run

Chinook salmon (*Oncorhynchus tshawytscha*). The work group is comprised of 11 individuals representing state and federal agencies, tribal interests, academic institutions, and private industry. The Western Division of the American Fisheries Society (AFS) has official representation in the work group. As AFS president, I was invited by both NMFS and the Western Division AFS to observe and to provide perspective as a member of a four-person steering committee with oversight responsibilities.

Members of the work group were deeply insightful, thoroughly professional, and absolutely respectful of one other. However, the issues addressed became increasingly complex. This should come as no surprise to persons with knowledge and experience in the science and management of Pacific salmon. Halfway through the second and final day of this meeting, I began to have serious doubts as to whether or not the work group would be able to accomplish the meeting's objectives. I shut my eyes and thought deeply about what I was experiencing with this group. Over and over again, silently to myself, I thought, "These are disciplined scientists. Their discipline will not allow them to move ahead until each element of their task is firmly founded and in good order. They are doing their job as scientists and addressing the trust our civilization has given them." My doubts regarding the prospects of the group meeting the objectives were shared by others on the steering committee.

Finally a break was called and the steering committee met. Somehow, some way, the work group had to move ahead. When the group reconvened, the steering committee challenged the morning's work and suggested starting all over again using a framework that had originally been provided to the group at the beginning of the meeting. There was dead silence in the room. Everyone in the room knew exactly what had to be done. It was time to shift gears and move forward…with courage.

The work group rejected the steering committee's suggestion of starting over again, electing instead to move ahead in their own fashion. They had, as they reminded the steering committee, been brought together for that purpose. The work group moved forward, in good order, and completed the day's objectives. Good science prevailed and was beautifully expressed.

Whether verbalized or not, I knew that members of the work group shared the dream of healthy salmon populations along the California coast. And, for that dream to become reality, they had no choice. They had to dwell in the realm of courage as well as in the realm of discipline.

The Dream that We form starts within us.

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JOURNAL HIGHLIGHTS:

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VOLUME 21
ISSUE 2
JUNE 2009

Tumors in Brown Bullheads in the Chesapeake Bay Watershed: Analysis of Survey Data from 1992 through 2006. Alfred E. Pinkney, John C. Harshbarger, and Michael A. Rutter, pages 71-81.

Virulence Variation of White Spot Syndrome Virus in Pacific White Shrimp *Litopenaeus vannamei.* S. E. Laramore, J. Scarpa, C. R. Laramore, and J. Lin, pages 82-90.

Optimizing Copper Sulfate Treatments for Fungus Control on Channel Catfish Eggs. David L. Straus, Andrew J. Mitchell, Ray R. Carter, and James A. Steeby, pages 91-97.

Are All Koi Ulcer Cases Associated with Infection by Atypical *Aeromonas salmonicida*? Polymerase Chain Reaction Assays of Koi Carp Skin Swabs Submitted by Hobbyists. Andrew E. Goodwin and Gwenn E. Merry, pages 98-103.

Assessment of Cellular and Functional Biomarkers in Bivalves Exposed to Ecologically Relevant Abiotic Stressors. Joanna Joyner-Matos, Jenessa Andrzejewski, Laura Briggs, Shirley M. Baker, Craig A. Downs, and David Julian, pages 104-116.

[Communication] **Evaluation of Sodium Carbonate Peroxyhydrate as a Potential Catfish Egg Disinfectant.** Brian C. Small, pages 117-123.

Identification of *Edwardsiella ictaluri* and *E. tarda* by Species-Specific Polymerase Chain Reaction Targeted to the Upstream Region of the Fimbrial Gene. Takamitsu Sakai, Kei Yuasa, Motohiko Sano, and Takaji Iida, pages 124-132.

North American Journal of Aquaculture

VOLUME 71
ISSUE 4
OCTOBER 2009

Survival and Passage of Ingested New Zealand Mudsnails through the Intestinal Tract of Rainbow Trout. R. Louise Bruce, Christine M. Moffitt, and Brian Dennis, pages 287-301.

Realized Heritability and Genetic Gain Estimates of Larval Shell Length in the Chinese Pearl Oyster *Pinctada martensii* at Three Different Salinities. Yuewen Deng, Shao Fu, Xiaodong Du, and Qingheng Wang, pages 302-306.

Effect of Postmanufacturing Processing and Shipping of Luteinizing Hormone Releasing Hormone Analog on Induced Ovulation for Production of Channel Catfish Female × Blue Catfish Male Hybrid Fry. Anang H. Kristanto, Gloria Umali, Renee Beam, and Rex A. Dunham, pages 307-311.

[Communication] **Evaluation of Zooplankton in Hatchery Diets for Channel Catfish Fry.** Charles C. Mischke, David J. Wise, and Todd S. Byars, pages 312-314.

[Communication] **Bacterial Bioaugmentation of Channel Catfish Ponds.** Craig S. Tucker, Susan K. Kingsbury, and Charles C. Mischke, pages 315-319.

Dietary Protein Source and Level Affects Growth in Neon Tetras. Wendy M. Sealey, Frederic T. Barrows, Mike Casten, and Ronald W. Hardy, pages 320-324.

[Technical Note] **Performance of Yellowstone and Snake River Cutthroat Trout Fry Fed Seven Different Diets.** Greg A. Kindschi, Christopher A. Myrick, Frederic T. Barrows, Matthew Toner, William C. Fraser, Jason Ilgen, and Linda Beck, pages 325-329.

[Technical Note] **One-Year Retention of Passive Integrated Transponders in Adult Muskellunge, and Applications to Broodstock Management.** Martin J. Jennings, Gene R. Hatzenbeler, and Jeffrey M. Kampa, pages 330-332.

Laboratory Dose Confirmation of Copper Sulfate for Treating Fungus on Channel Catfish Eggs. David L. Straus, Andrew J. Mitchell, Andrew A. Radomski, Ray R. Carter, and James A. Steeby, pages 333-338.

Performance of Spring Chinook Salmon Reared in Standard Raceways and in Michigan Raceways with Oxygen Supplementation. Lance R. Clarke, William A. Cameron, R. Wes Stonecypher Jr., Michael C. Hayes, and Richard W. Carmichael, pages 339-347.

Comparative Swimming Performance of Juvenile Blue Catfish and Hybrid Catfish. Rachel Venn Beecham, C. Douglas Minchew, Glenn R. Parsons, and Susan B. LaBarre, pages 348-353.

[Communication] **A Vertical-Lift Incubator (the "Seesaw") Designed for Channel Catfish Egg Masses.** Les Torrans, Brian Ott, Robert "Shorty" Jones, Robert Jones Jr., Jeff Baxter, Bill McCollum, Andrew Wargo III, and Jimmy Donley, pages 354-359.

Captive Breeding of Endangered Mohave Tui Chub. Thomas P. Archdeacon and Scott A. Bonar, pages 360-362.

Saturated Lipid Sources in Feeds for Sunshine Bass: Alterations in Production Performance and Tissue Fatty Acid Composition. Jesse T. Trushenski, pages 363-373.

[Technical Note] **Characterization of Red Drum Microsatellite Markers in Spotted Seatrout.** Mark A. Renshaw, Tom R. Gawriluk, and John R. Gold, pages 374-379.

Effects of Praziquantel on Eggs of the Asian Tapeworm *Bothriocephalus acheilognathi.* S. Jason Kline, Thomas P. Archdeacon, and Scott A. Bonar, pages 380-383.

Compensatory Growth after Winter Food Deprivation in Hatchery-Produced Coho Salmon and Chinook Salmon Smolts. Stan P. Triebenbach, William W. Smoker, Brian R. Beckman, and Rick Focht, pages 384-399.

FISHERIES CURRENTS
SCIENCE NEWS FROM AFS

2008 Robert L. Kendall Best Paper in *Transactions of the American Fisheries Society*

Predicting the effects of climate change on marine fisheries is a daunting but crucial task for today's fisheries scientists. Small shifts in temperature and currents alter how nutrients are distributed, thus affecting the growth of plankton and eventually fish. Fortunately, two tools are available to help: data from previous climate shifts and computer models that can simulate lower trophic-level dynamics and its effects on fish growth and population dynamics. In a recent award-winning paper in *Transactions of the American Fisheries Society,* U.S. and Canadian scientists used climate and catch data from 1962–2002 to configure two coupled computer models for Pacific herring—one for the nutrient-phytoplankton-zooplankton relationship and one for the bioenergetics and population dynamics of herring in the upwelling system off the west coast of Vancouver Island. The researchers found that Pacific herring body weight and population growth were highest under the climate regime of 1962-1976, intermediate from 1977-1988, and lowest from 1989-1999. The authors encourage more use of such coupled models in developing fisheries management recommendations to adjust harvests during unfavorable climatic conditions. **Climate Regime Effects on Pacific Herring Using Coupled Nutrient-Phtyoplankton-Zooplankton and Bioenergetics Models,** by *Kenneth A. Rose, Bernard A. Megrey, Douglas Hay, Francisco Werner, and Jake Schweigert. Transactions of the American Fisheries Society* 137:278-297. Rose may be contacted at karose@lsu.edu.

2008 Mercer Patriarche Best Paper in the *North American Journal of Fisheries Management*

Traditional single-species modeling approaches for commercial marine fisheries species such as Atlantic herring assume that the rate of natural (non-fishing) mortality is fixed. However, newer multispecies complex models are better able to account for the varying effects of natural predation on a population. As a keystone prey species, Atlantic herring are eaten by predators ranging from cod and sharks to whales, porpoises, and even seabirds. In a recent award winning paper in the *North American Journal of Fisheries Management,* scientists from the National Oceanic and Atmospheric Administration's Northeast Fisheries Science Center in Woods Hole, Massachusetts, calculated how many kilo-metric tons were being consumed by Atlantic herring's 30 major predators in the Gulf of Maine-George Bank region. The researchers found that the combined impact of fishing and predation was very large in the 1960s and early 1970s, causing a precipitous decline in the herring population. After two decades of recovery, predation of Atlantic herring peaked in the 1990s at 333 kt (333,000 tons) annually, when predator consumption exceeded fishery landings by a factor of three, and later declined due to fisheries removing the predators themselves. The authors note that this ecosystem approach indicates a lower sustainable harvest level than single-species assessments. **An Ecosystem Approach for Assessment Advice and Biological Reference Points for the Gulf of Maine-Georges Bank Atlantic Herring Complex,** by *W. J. Overholtz, L. D. Jacobson, and J. S. Link. North American Journal of Fisheries Management* 28:247-257. Overholtz may be contacted at william.overholtz@noaa.gov.

2008 Best Paper in the *Journal of Aquatic Animal Health*

A fish introduction from nearly 50 years ago is offering intriguing insights into both how fish can adapt to disease and how introduced populations genetically diverge from their source. In the late 1960s, Chinook salmon from the Green River, Washington, were introduced into Lake Michigan to provide a new sport fishery following the decline of native Great Lakes species. However, from 1988-1992, large numbers of Chinook in Lake Michigan died due to bacterial kidney disease (BKD). In a recent award winning paper in the *Journal of Aquatic Animal Health,* scientists from Wisconsin and Washington tested the disease resistance of Green River Chinook versus their Lake Michigan descendents. They found that the Wisconsin Chinook had significantly greater survival to BKD, possibly due to pathogen-driven genetic selection after the earlier fish kills. However, the Green River fish had much better survival against a marine disease pathogen called *Listonella anguillarum* that the freshwater Lake Michigan Chinook population no longer encounters. Genetic analysis shows that the Green River and Wisconsin fish are indeed closely related genetically, although with a small but significant divergence after an estimated 13 generations of separation. **Decreased Mortality of Lake Michigan Chinook Salmon after Bacterial Kidney Disease Challenge: Evidence for Pathogen-Driven Selection?** by *Maureen K. Purcell, Anthony L. Murray, Anna Elz, Linda K. Park, Susan V. Marcquenski,*

Continued on page 622

UPDATE: LEGISLATION AND POLICY

Elden Hawkes, Jr.

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

Oversight hearing on Magnuson-Stevens implementation

The House Subcommittee on Insular Affairs, Oceans, and Wildlife held an oversight hearing to discuss the implementation of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) of 2006. This hearing was composed of two panels of participants whose affiliation ranged from federal agencies to academics.

Some of the witnesses stated that the regional fisheries counsels have made significant progress in achieving sustainable fisheries, with many of the mandated specified tasks of the MSA nearing completion. They further elaborated that the number of federally-managed fisheries subject to overfishing is declining at a modest rate and there are plans in place to end overfishing in all fisheries that require rebuilding. The witnesses also stated that the MSA has also improved recreational fishery data collection efforts. Other witnesses said that ending overfishing is an absolute necessity to recover stocks and to provide additional opportunities for commercial and recreational fisheries. They explained that the social and economic impacts of overfishing will be felt immediately, and concluded that ending overfishing and recovering overfished stocks will pay significant dividends in the long term.

All witnesses agreed that the MSA will improve the management of marine resources, help to prevent healthy stocks from being overfished, and rebuild currently overfished stocks. These healthier stocks would produce greater catches and be more stable and resilient to environmental changes. The requirements of MSA are moving both science and management in the right direction. Ultimately the MSA will lead to substantial progress toward economically viable commercial and recreational fisheries.

CEQ listening session on water resources and climate change

In October 2009, the White House Council on Environmental Quality's (CEQ) water resources work group held a listening session to discuss stakeholder issues regarding their views on water resource and climate change adaptation issues. The session is part of an effort to develop recommendations for federal agencies on their programs for adapting to climate change. The session focused on stakeholders' input on the following questions:

- What do you see as the key impacts of a changing climate for water resources?
- Are there key programs, policies, or other actions that federal agencies should adopt to support or guide adaptation to climate change?
- Are there effective models for coordination among federal agencies, states, tribes, local governments, and others on water resources and climate change issues that the workgroup should consider in its work?
- How can water resources and climate change adaptation planning be coordinated or integrated with other water resources planning efforts? Can you provide examples of such coordination already underway?
- Are there water resources and climate change studies or reports that the workgroup should consider in its work?

Many stakeholders said that consequences such as flooding due to increased precipitation, saltwater infiltration into freshwater regions, and changes in ocean salinity were some of the major impacts that needed to be addressed regarding climate change. Others expressed a desire for the creation of a cabinet-level water resources council or a "water czar" to guide adaptation programs. Many of the participants stated that the states' role in water allocation should be emphasized, as well as ocean fisheries management plans, when it comes to effective models of coordination. Others also said that many tribal governments need help from federal agencies in the drafting and implementing climate change action plans. All of the participants stressed the need for continued leadership in developing requirements for water resource climate change adaptation plans.

Freshwaters in the Public Eye: Understanding the Role of Images and Media in Aquatic Conservation

Our ability to perceive quality in nature begins, as in art, with the pretty. It expands through successive stages of the beautiful to values as yet uncaptured by language.

—*Aldo Leopold, A Sand County Almanac*

Jeremy B. Monroe, Colden V. Baxter, Julian D. Olden, and Paul L. Angermeier

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INTRODUCTION

Freshwater ecosystems represent one of the Earth's richest pools of biological diversity, and are also hotspots of human use and alteration. Consequently, freshwater fishes and numerous other aquatic species are declining and disappearing at rates exceeding most other ecosystems (Cambray and Bianco 1998; Dudgeon et al. 2006). Unfortunately, freshwater biodiversity is not only critically imperiled, it is also highly obscure (Harrison and Stiassny 1999). As threats to freshwater ecosystems continue to grow, the vast majority of their inhabitants remain "out of sight, and largely out of mind" (Rolston 1991). This lack of public awareness of freshwater life may ultimately limit freshwater conservation as a popular cause, or movement.

By its nature, aquatic life is inherently less visible to human eyes, and so images, such as photographs and video, play a critical role in visually connecting freshwater ecosystems to their would-be stewards. Images are capable of conveying information and evoking emotion at a glance, and are generally more intuitive, more quickly assimilated, and often more memorable than verbal description (Dondis 1973; Messaris 1996). In fact, images and visual media have long played a strategic role in effective conservation campaigns, from the creation of the national parks to modern marine conservation causes (see Figure 1). And while images by no means replicate human experiences in the natural world, they are a remarkably effective surrogate to enlighten audiences about natural ecosystems and their values (Cahn and Ketchum 1981; Bouse 2000).

Figure 1. Images can convey the beauty and values that can form a conservation ethic, just as the landscape photographs and paintings of William Henry Jackson, Thomas Moran, and Ansel Adams (left to right) helped create and grow the U.S. National Park System, the paintings of John James Audubon created a popular appreciation for bird diversity and beauty, and the books and films of Jacques Cousteau broadened our modern perspective of marine life.

The challenge of making freshwater conservation a more popular cause merits a deeper examination of the images that represent freshwater life, especially those seen in popular media. Somewhat introspectively, we consider below our concern that a limited set of images depicting freshwater life may confine our ability to communicate broader values of freshwater ecosystems, and may ultimately limit our capacity to inspire a more inclusive movement to conserve them. We emphasize how freshwater life is portrayed in popular media and everyday images, and suggest a more strategic selection of images to reshape how society perceives and values freshwater ecosystems. We focus on fishes because they are among the most obvious and widely recognized of freshwater biota.

THE FRESHWATER IMAGE: A FISH OUT OF WATER

The Earth's rivers, lakes, and wetlands provide vital resources to virtually every one of its human inhabitants (MEA 2005). Yet, the responsibility of conserving freshwater ecosystems has been shouldered mainly by the recreational users of these ecosystems. Stewards from the angling, hunting, and boating communities have long been the most active advocates for aquatic conservation (Fedler 2001), and their work has done much to protect and restore freshwater ecosystems. However, the challenges posed by the freshwater conservation crisis are far too great for these stewards alone. Given the vital importance of freshwater ecosystems to humankind, we ask, why isn't the conservation of freshwater ecosystems a more popular cause?

A key to understanding why the conservation of freshwater ecosystems has such a limited following may lie in how freshwater life is portrayed in media and perceived by the public. A passing glance at a magazine rack, television programming, and popular internet websites reveals a narrow view of freshwater life. In these popular sources of public information and entertainment, the vast majority of freshwater species are simply unseen, and therefore unknown to most people. Meanwhile, a handful of celebrated sportfishes are commonly seen in popular media aimed at anglers, and are no less visible in family albums and on office walls.

A closer examination of the common images of freshwater life reveals an issue that is perhaps more problematic than mere obscurity. Almost invariably, popular images portray sportfishes and most other freshwater species after they have been "landed" or otherwise extracted from their aquatic habitat (Figure 2). In these images, aquatic organisms are far removed from their natural environment and behavior, which precludes an aquatic, and perhaps empathetic, perspective of their lives and their world. Moreover, these struggling or dead organisms are commonly seen "at the hands" of both anglers, and biologists, portraying a conquering image (sensu Leopold 1949). Collectively, these commonly seen images appear more human-centered, and represent a set of values and aesthetics that are somewhat exclusive to the angling community.

Figure 2. The "popular image" of freshwater life emphasizes the values and aesthetics surrounding game fish and angling culture through various depictions of conquering anglers and captured quarry, and which may be lost on or misinterpreted by the non-angling public.

While there is little public opinion research to draw from, a casual look at popular culture suggests that aquatic life is far more appreciated for its utilitarian value than for its ecological and intrinsic value. This imbalanced value is exemplified in the common perception of certain species as "trash fish" and the common synonymy of "minnows" and "bait," yet is perhaps best illustrated in the U.S. state fishes. Of the roughly 800 freshwater fish species in the United States, only 18 species are represented in the 43 freshwater state fishes (i.e., numerous fishes are shared by several states), and all of these are considered game species. When compared to the state birds—of which over 90% are non-game species—it seems that the public value for fish is more resource-based and utilitarian, and suggests that the U.S. public may draw a meaningful distinction between fish and wildlife.

Given how freshwater organisms are seen—and unseen—in the public eye, a fundamental constraint to inspiring broader public support for freshwater conservation is the narrow and exclusive set of values that are being emphasized in everyday images and in popular media.

JUST ADD WATER: REVEALING THE HIDDEN VALUE OF FRESHWATER ECOSYSTEMS

While the imperilment of freshwater life has become a global crisis deserving general understanding and sympathy, the public remains scarcely aware of freshwater ecosystems, their remarkable biodiversity, and their importance to society. Freshwater organisms and communities are seldom-covered subjects of television, magazines, and websites, and their nature is rarely explored from an aquatic perspective. Yet with such unique and diverse forms of life, freshwater ecosystems hold great potential to captivate public interest and motivate conservation.

Though rarely seen in popular media, underwater images of fish and other freshwater life in their aquatic habitat can more naturally convey the intrinsic and ecological value of these organisms, as well as their evolutionary, and even spiritual aesthetics. These images celebrate the aquatic world by depicting the natural beauty and behavior of freshwater life, the splendor and uniqueness of freshwater environments, and the intricate relationships among species and their habitats (Figure 3). In their natural medium, free of human hands or devices, organisms appear independent of humankind, and their intrinsic value is therefore made more obvious. Indeed, the vision of an organism behaving naturally and relating to its natural environment is precisely what can allow us to sympathize or even empathize with other species (Wilson 1986), and appreciate their significance in our own world or worldview. It is these ecological, evolutionary, and spiritual aesthetics that will presumably resonate more deeply with the broader public, and are most likely to drive conservation movements (Jepson and Canney 2003).

Figure 3. The seldom seen "aquatic image" of freshwater life emphasize the values and aesthetics surrounding freshwater biodiversity through images that depict remarkable environments, behaviors, and interactions, and that can inspire sympathy and stewardship in a broader public.

TOWARD AN IMAGE-CONSCIOUS COMMUNICATION STRATEGY IN FRESHWATER SCIENCE, CONSERVATION, AND EDUCATION

When one man, for whatever reason, has the opportunity to lead an extraordinary life, he has no right to keep it to himself

—*Jacques Yves Cousteau*

Freshwaters have had neither a Jacques Cousteau nor an inspired renaissance of visual artists, writers, or media specialists to celebrate the aesthetics and intrinsic values of aquatic ecosystems and biodiversity (see inset). In our view, the opportunity to restore a balanced public image of freshwater ecosystems lies in the hands of those who know these ecosystems and their diverse inhabitants. Aquatic scientists, conservationists, educators, anglers, and enthusiasts (hereafter the "freshwater community") have a unique perspective that can help revive the image of freshwater life amongst a broader public. If we ourselves do not assume a greater responsibility for the public awareness of freshwater ecosystems and biodiversity, their value will continue to be underrepresented in popular media and images, as well as in our own public education and outreach efforts. In advocating a deeper appreciation of freshwater ecosystems, we should be more conscious of public perceptions of freshwater life, become more familiar with the psychology of stewardship, and conduct more research in these arenas.

To guide the public toward a more appreciative perspective of freshwater ecosystems, the freshwater community must take a more image-conscious approach to education, outreach, and communication. As we hope to have illustrated, images send powerful messages, and it is dangerous to ignore the values represented by the images we choose to present publicly. When sharing ideas or conveying messages about freshwater biodiversity, we suggest a more deliberate use of images to express not only the knowledge we intend to convey, but also the value and appreciation we have for these organisms. Such effort will doubtless require greater use of underwater and natural history images to revive the intrinsic values and ecological aesthetics that have been long ignored. Arguably, we may now need to over-represent these values in our communications.

The most immediate need in this effort is for the freshwater community to create and share a more balanced collection of images for outreach and education. This demands that we increase our efforts in compiling and sharing our natural history images, encourage and celebrate our aquatic photographers and artists, and become more proficient with the tools of image creation. We might further consider underwater and natural history photography and illustration as fundamental skills in fishery and aquatic biology. In our public communications, we suggest collaborating with artists, media specialists, and visual communicators. In all of these efforts, we should capitalize on the increased accessibility of digital underwater camera systems and editing software.

A more balanced and extensive collection of freshwater-related images would almost certainly facilitate an increased outreach effort among the freshwater community. Freshwater outreach is in many ways image limited, and would-be lectures, slide shows, websites, and articles may lack critical visual content. In fact, mass media outlets commonly judge potential stories as much on their visual content as on their verbal content. Finally, given that technical language often impedes the outreach of scientists and conservationists (Jacobson 1999), an increased means of visual expression may be empowering toward these efforts.

Ultimately, if the freshwater community is to place increased emphasis on effective public education and outreach (see Angermeier 2007), images and visual communication have a crucial role to play. There is a wonderful surprise awaiting society in freshwater ecosystems, and a great awakening yet to come for freshwater conservation. The freshwater community possesses both the knowledge and passion to rouse the future stewards of these vital ecosystems. In crafting our educational and conservation messages, we should choose images as carefully as we choose words.

The marine image: an envious look

Marine ecosystems once had an image problem similar to that in fresh waters, before the visual explorers of marine ecosystems broke a stubborn surface tension to create what is now a more balanced public perception of marine life. The innovative explorations of Jacques Cousteau and other filmmakers and photographers created a frontier of images for popular audiences to explore, and the generations they inspired continue to create images that capture marine life from tide pools to the deep ocean trenches. In both mass media and outreach, it is as common to see an image of a shark underwater as it is to see one hanging at the end of a pier, and nongame fishes such as those that inhabit coral reefs are perhaps as well known as game species. Given this more balanced exposure, it is somewhat less surprising that millions of people have been inspired to "dive into" these environments through recreational snorkeling and SCUBA diving, or that marine biology is such an aspired-to field among students. Although the public image of ocean life may still need some work (see Auster et al. 2009), we wonder how much more daunting marine conservation challenges would be without the intrinsic values and aesthetics that have been promoted through images and media.

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The Bait Industry as a Potential Vector for Alien Crayfish Introductions: Problem Recognition by Fisheries Agencies and a Missouri Evaluation

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Rusty crayfish (*Orconectes rusticus*)

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ABSTRACT: "Bait-bucket introductions" related to the fishing bait industry are the suspected primary cause of alien (non-indigenous) crayfish introductions that have damaged North American aquatic ecosystems. Our 2008 survey of U.S. and Canadian fisheries agencies revealed that 49% of respondents reported aquatic resource problems that were believed to have been caused by bait-bucket introductions of alien crayfishes. Most respondents reported existing regulations designed to address those problems; however, only 4% prohibited the use of live crayfish bait. Our 2002–2007 examination of Missouri bait shops revealed sales of illegal and invasive alien crayfishes by bait shop proprietors who could not identify the species they were selling. Fisheries agencies should consider more effective bait regulations and education to prevent negative impacts to aquatic biodiversity, habitat, and fisheries that can result from alien crayfish introductions.

La industria de la carnada como potencial vector de introducción de langostino: reconocimiento del problema por agencias de pesquerías y una evaluación en Missouri

RESUMEN: Se sospecha que la introducción de especies exóticas a través de cubetas con carnada, ha impactado negativamente los ecosistemas acuáticos de Norteamérica. Un muestreo que realizamos en el 2008 a agencias de pesquerías en Canadá y Estados Unidos de Norteamérica, reveló que el 49% de los corresponsales reportaron problemas relacionados a recursos acuáticos que se cree fueron causados por introducción de langostinos exóticos en cubetas con carnada. La mayor parte de los corresponsales reportaron la existencia de regulaciones para abordar el problema; sin embargo, solo el 4% de éstas prohíbe el uso de langostinos vivos como carnada. Nuestro examen realizado a tiendas de carnada en Missouri durante el periodo 2007-2007, reveló venta de langostinos ilegales e invasivos por parte de los propietarios de las tiendas, quienes no pudieron identificar las especies que vendían. Las agencias de pesquerías debieran contemplar regulaciones y programas de educación más efectiva en cuanto al uso de carnada para prevenir los impactos negativos que la introducción de langostinos exóticos tiene sobre la biodiversidad acuática, los hábitats y las pesquerías.

INTRODUCTION

Crayfishes are an important component of many North American freshwater ecosystems and are considered to be "keystone species" (sensu Paine 1969) or "ecological dominants" (sensu Simberloff 1998) by many ecologists (Momot et al. 1978; Creed 1994; Parkyn et al. 1997). They process organic matter (Momot et al. 1978; Parkyn et al. 1997), affect the physical structure of aquatic habitats (Statzner et al. 2003; Creed and Reed 2004) and the structure of benthic invertebrate communities (Momot et al. 1978; Rabeni et al. 1995; Whitledge and Rabeni 1997), transfer energy among trophic levels (Momot et al. 1978; Momot 1995), and are documented prey for over 200 species of mammals, birds, reptiles, amphibians, fishes, and insects (DiStefano 2005), including many important sport fishes (summarized in DiStefano 2005) . About 77% of the world's crayfish fauna (405 species and subspecies) inhabit North America (Taylor 2002). Many of these species have small natural ranges, often limited to a single drainage basin, and are therefore vulnerable to extirpation caused by habitat or ecosystem alterations (Lodge et al. 2000a; Taylor et al. 2007).

Bait-bucket introductions are believed to be among the most common vectors for alien aquatic species. Nearly half of U.S. and Canadian fisheries agencies reported aquatic resources problems believed to be caused by bait-bucket introductions of alien crayfishes.

At least 363 native crayfish species occur in the United States and Canada and 48% of these crayfishes require conservation (listed as endangered, threatened, or vulnerable species; Taylor et al. 2007). Lodge et al. (2000a) cited the introduction of alien (non-indigenous; see Occhipinti-Ambrogi and Galil 2004) crayfishes as the single greatest threat to crayfish biodiversity worldwide and implicated the live bait trade as the most important vector for the introduction of alien crayfishes in North America. In a series of recommendations to reduce alien crayfish introductions, Lodge et al. (2000b) called for all U.S. states to ban the use of live crayfishes as bait. In response to this recommendation, we conducted an evaluation of crayfish bait sales in the state of Missouri to gain insight into the potential for the Missouri bait industry to act as a vector for the introduction of alien crayfishes. Additionally, we conducted a survey of U.S. state and Canadian provincial and territorial fisheries agencies to determine the extent of bait-bucket crayfish introduction problems and the level of regulation used by these agencies to control introductions.

Many recent studies have documented aquatic resource problems associated with introductions of alien crayfishes (Lodge et al. 2000a; Taylor et al. 2007). Introduced alien crayfishes have displaced native crayfishes and reduced biodiversity (Lodge et al. 1986; Light et al. 1995; Daniels 1998); adversely affected or displaced native amphibians (Gamradt and Kats 1996; Kats and Ferrer 2003), reptiles (Fernandez and Rosen 1996b), and fishes (Guan and Wiles 1997; Dorn and Mittelbach 1999); adversely affected sport fisheries (Hobbs et al. 1989; Dorn and Mittelbach 1999; Wilson et al. 2004); and altered the structure and function of stream, lake, and marsh communities (Feminella and Resh 1989; Olsen et al. 1991; Charlebois and Lamberti 1996). Introductions of two crayfish species in particular, the rusty crayfish (*Orconectes rusticus*) and the red swamp crawfish (*Procambarus clarkii*), have negatively impacted aquatic ecosystems at many localities (Hobbs et al. 1989; Taylor 2002). *Orconectes rusticus* is native to drainages in Indiana, Ohio, Kentucky, and the southeastern corner of Michigan, but has been introduced to drainages in 17 additional U.S. states and 2 Canadian provinces (Taylor et al. 2007). Due to its aggressive behavior and larger size, *O. rusticus* commonly reaches high densities in introduction locations, resulting in displacement of native crayfishes (Momot 1996; Taylor and Redmer 1996; Olden et al. 2006), destruction of important macrophyte beds and decreased macrophyte species richness (Wilson et al. 2004), and declines in native fish populations (Wilson et al. 2004). Likewise, *P. clarkii* is native to 12 states in the south-central United States and has been introduced to 9 western and 6 eastern states (Taylor et al. 2007). In the western United States, *P. clarkii* has been reported to consume eggs of endangered fish (Mueller et al. 2006) and adversely affect amphibian breeding (Gamradt et al. 1997). Introductions of *P. clarkii* and other North American crayfishes that carry the plague fungus, *Aphanomyces astaci*, have decimated native crayfish populations across Europe (Lodge et al. 2000a; Gil-Sánchez and Alba-Tercedor 2002) and adversely affected native amphibian breeding and species richness (Cruz et al. 2006; Rodríguez et al. 2005).

Missouri has a diverse crayfish fauna, with at least 35 native species from 6 genera. Eight species are endemic to relatively small drainages in the Missouri Ozarks Ecoregion and an additional 12 species have native distributions limited to only parts of southern Missouri and neighboring Arkansas, Oklahoma, and Kansas (Pflieger 1996). Due to the limited distribution and ecological importance of many crayfish species, effects of introduced alien crayfishes pose a serious threat to aquatic ecosystems, fisheries, and crayfish biodiversity throughout Missouri and North America. Alien crayfish introductions were recently documented in two drainages (Riggert et al. 1999; Magoulick and DiStefano 2007) in southern Missouri. In both locations, alien crayfishes have the opportunity to interact with native species that are state listed as imperiled (Missouri Natural Heritage Program 2009), and listed by the American Fisheries Society as threatened (Taylor et al. 2007). Three of those native imperiled crayfishes have already disappeared from significant portions of their ranges that are occupied by alien species (Riggert et al. 1999; Magoulick and DiStefano 2007). Other potential effects to these aquatic systems remain unknown. Additional alien crayfish introductions have been noted in other Missouri drainages but the ecological effects of these have not been documented.

We are unaware of any studies that have assessed the pervasiveness of alien crayfish introductions across the United States and Canada. Several authors have implicated bait-bucket introductions by anglers as a major cause of these problems on the continent, and controlling the sale and use of live crayfishes for fishing bait has been cited as a legitimate management alternative (Eng and Daniels 1982; Ludwig and Leitch 1996; Lodge et al. 2000a, 2000b; Burkholder and Wallace 2001). Anglers often release live bait in waters near where it was purchased, but they also often travel across basin boundaries, potentially releasing live bait in other watersheds (Litvak and Mandrak 1993; Ludwig and Leitch 1996). At least three U.S. states (Arizona, Virginia, and Wisconsin) have banned either the use or sale of live crayfishes as bait and the Canadian province of Manitoba

has banned the possession of crayfishes on all waters (Manitoba Angler's Guide 2008).

Current Missouri regulations allow bait vendors to sell only the following four crayfish species that are native to the state and appear on the Missouri Approved Aquatic Species List (MAASL): the virile (northern) crayfish (*O. virilis*), calico (papershell) crayfish (*O. immunis;* this species was added to the MAASL in 2004 following the first year of this study), White River crawfish (*P. acutus*), and *P. clarkii* (Missouri Department of Conservation [MDC] 2009). Crayfishes sold in bait shops must not be obtained from public waters of the state (i.e., they must come from a private commercial source either from inside or outside the state, which ironically may present potential population genetics and disease transfer problems), and bait vendors must keep written receipts documenting the source of their crayfish stocks (MDC 2009). In addition, anglers possessing a valid Missouri fishing license may harvest up to 150 crayfishes per day from waters of the state for use as bait, but they may not be released into waters from which they did not originate (MDC 2009).

Interestingly, only one of the species on the MAASL, *O. virilis*, occurs throughout most of the state. The historical widespread distribution of this species in Missouri may have been smaller, and much of its current distribution is believed to be due to human introductions (W. Pflieger, MDC retired, pers. comm.), possibly via bait sales and subsequent illegal releases by anglers. The other three species on the MAASL have more limited distributions; *O. immunis* is native to the northern half of Missouri and western Osage River basin whereas *P. acutus* and *P. clarkii* were limited historically to a small portion of southeast Missouri, and *P. acutus* also occurred historically in the main-stem Mississippi River (Pflieger 1996). This suggests that even legal sales of crayfishes (as currently allowed by the MAASL) might be a vector for alien species introductions throughout the state. Additional concern is warranted because species on the MAASL have caused problems elsewhere. *Orocnectes virilis* has adversely effected native amphibians, reptiles, and invertebrates (Fernandez and Rosen 1996a; Fernandez and Rosen 1996b); displaced native crayfish populations (Schwartz et al. 1963); and demonstrated a capability to impact native fishes in North America (Carpenter 2005; Rogowski and Stockwell 2006). As previously mentioned, *P. clarkii* has caused numerous problems in Europe and the western United States, and *P. acutus* is suspected of causing declines of native crayfishes in New York state (Pickett and Sloan 1985). Furthermore, anglers that use crayfishes collected from the wild as bait may also contribute to introduction of many other alien crayfish species due to their lack of knowledge of regulations prohibiting the release of live bait and angler travel between bodies of water and across watershed boundaries.

The wider goal of this study was to determine whether the incidence of bait-bucket introductions of alien crayfishes is problematic as perceived by U.S. state and Canadian provincial and territorial fisheries agencies. We also chose to focus in detail on the role of bait shops in one state, Missouri, as a potential vector for the introduction of illegal native or alien crayfish species into Missouri waters. Specific objectives were to determine:

1. The proportion of U.S. state and Canadian provincial and territorial fisheries agencies that are aware of aquatic resource problems with freshwater alien crayfish species in which bait-bucket introductions are a suspected cause, and the regulatory responses to those problems.
2. The proportion of Missouri bait shops that conducted illegal crayfish sales (illegal because crayfish species were not on the MAASL or were obtained from illegal sources),
3. The presence of illegal and possibly invasive alien species in Missouri's bait industry,
4. If legal native crayfishes species were sold in geographic locations outside of their known historical range,
5. Locations (state of origin) of commercial sources (distributors) of crayfishes sold in Missouri bait shops, and
6. Whether bait shop owners/managers knew what crayfish species they sold.

The introduction of alien crayfish is a significant threat to the conservation of aquatic biodiversity and ecosystem function. Understanding the roles of the bait industry in the introduction or prevented introduction of alien crayfishes is an essential step towards effective management of invasive species and aquatic resources.

METHODS

Survey of U.S. and Canadian fisheries agencies

We sent an e-mail survey to fisheries agency chiefs or administrators in all 50 U.S. states, 10 Canadian provinces, and 3 Canadian territories on 10 January 2008, preceded by an introductory e-mail notification from the MDC Fisheries Division Chief, and followed by an e-mail survey reminder on 16 January 2008. We collected responses through February 2008. The survey contained two questions (second question with multiple parts; Table 1) requiring simple "yes" or "no" responses. However, the last portion of the second ques-

Table 1. Responses to e-mail survey of fisheries chiefs/administrators from 50 U.S. states, 10 Canadian provinces, and 3 Canadian territories about alien crayfish introductions. Survey had two questions, with multiple parts to the second question (parts "a" through "f" below). Overall response rate was 78% (n = 49). Frequencies (%) of "yes" and "no" responses are provided with actual response numbers in parentheses. Rows where cumulative responses do not sum to 49 indicate item nonresponse.

Question	Response	
	Yes	No
1. Is your agency aware of any aquatic resource problems with freshwater alien (non-indigenous) crayfish species in your state or province in which "bait-bucket introductions" are a suspected cause?	49% (24)	51% (25)
2. Has your state/province implemented any of the following management strategies or regulations to avoid or in response to problems caused by "bait-bucket introductions" of alien (non-indigenous) freshwater crayfish?[1]		
a. Prohibit the use of all live crayfish as bait.	4% (2)	94% (45)
b. Restrict the use of live crayfish as bait.	39% (18)	61% (28)
c. Restrict the release of live crayfish bait into natural waters.	58% (28)	42% (20)
d. Restrict the sale of live crayfish as bait.	37% (17)	63% (29)
e. Restrict sales of crayfish bait to only certain species.	27% (12)	73% (33)
f. Prohibit or restrict the use of dead crayfish as bait.	6% (3)	94% (46)

[1]Question number 2, part "g" provided respondents the opportunity to provide any other information that they deemed important or relevant to management strategies and/or regulations.

tion (part "g") provided respondents the opportunity to include any other information that they deemed important or relevant to management strategies and/or regulations.

Survey of Missouri bait shops

Development of bait shop survey database.—During autumn of 2002 we compiled a computerized list of 370 Missouri potential bait vendors (Figure 1) from several sources including Internet telephone listings and web searches, and consultation with the Missouri Department of Agriculture and MDC regional fisheries and law enforcement staff. All 370 shops were contacted during a December 2002 telephone census to determine whether and when (time of year; DiStefano et al. 2008a) they sold crayfishes. Businesses that did not answer their telephones after two calls during standard business hours (34 shops) or that had disconnected telephone numbers (48 shops) were removed from the list. This census resulted in a database of 135 bait shops that indicated they sold crayfishes sometime during the year.

Bait shop survey.—Responses from the telephone census were used to generate a list of bait shops to be surveyed (80 shops in 2003, 98 shops in 2004; Figure 2). The 2003 survey was conducted by MDC law enforcement staff (conservation agents) during one day (4 April 2003) to minimize communication among shops and reduce potential sampling bias. This sampling period was selected to coincide with availability of crayfishes in shops (determined in previously described telephone census) and the limited availability of conservation agents. We also considered the seasonal availability of reproductively active (form I) male crayfishes, which are most reliable for species identification (Hobbs 1976; Pflieger 1996), and occur during early autumn through late spring for many Missouri species. Seventy-four shops were successfully surveyed in April 2003 (six visited shops were closed). During each shop visit, agents purchased a randomly-selected sample of three dozen crayfishes (or all crayfishes in the shop if that number was less than three dozen), sealed them in airtight plastic bags, froze them to preserve color and integrity (DiStefano et al. 1994), and transported the frozen samples to a central laboratory for taxonomic identification.

To determine if a greater number of crayfishes with an acceptable proportion of form I males could be collected by sampling bait shops later in the spring (in preparation for the 2004 sample), 16 shops were visited again during 7–10 May 2003. These shops were closed or did not possess crayfishes during the April 4th survey, but they indicated they would be receiving crayfishes later in the spring. Conservation agents were not available to inspect shop receipts during the May 2003 16-shop survey.

The 2004 sampling trips occurred about 10 days later in the year (13–15 April) than in 2003 due to availability of staff. Twenty-five additional shops that had indicated in the telephone census that they typically sold crayfishes by late April or early May were added to the 2004 sampling list for a total of 98 surveyed shops in 2004 (Figure 2). Agents followed similar procedures as in 2003.

Upon each visit, agents inspected each bait shop's records and receipts during both years to determine the source for crayfish stocks and assess whether shops were in compliance with regulations requiring bait vendors to have dated receipts indicating the commercial source of their bait stock. If a shop had no records for its stock, the agent gathered as much information as possible about the source of the bait from the shop attendee. Agents recorded all information on provided datasheets (available in DiStefano et al. 2008a).

Taxonomic identifications were performed on thawed specimens in the laboratory with dichotomous crayfish keys for North America (Hobbs 1976) and Missouri (Pflieger 1996). All form I males were identified to species. Positive species identifications

Figure 1. Location of potential bait shops (*N* = 370) surveyed by telephone in 2002. When multiple bait shops were located within the same town, a single point represents the town location.

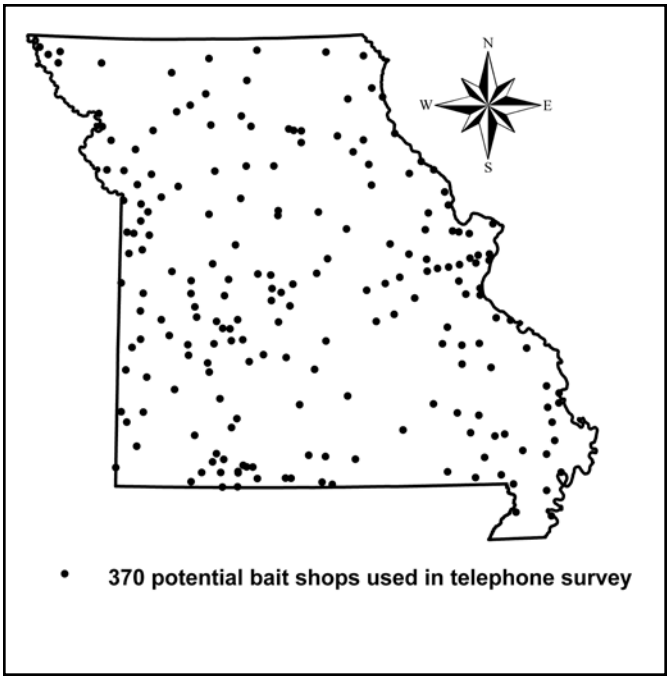
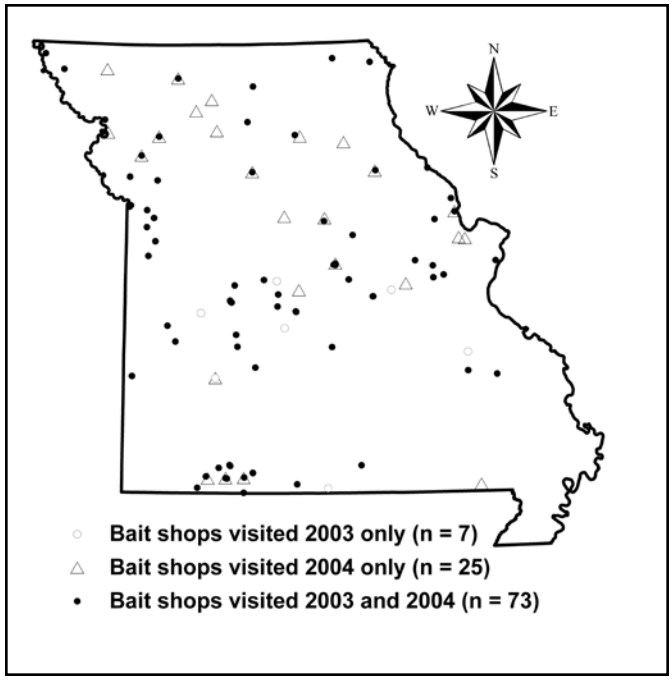


Figure 2. Location of bait shops visited by agency personnel in 2003 and 2004 (*n* = 105). When multiple bait shops were located within the same town, a single point represents the town location.



were made for all form II (reproductively inactive) *Procambarus* spp. specimens and many *Orconectes* spp. specimens that were in good physical condition; the remaining form II males were identified to genus. Female crayfishes were enumerated but not taxonomically identified; therefore all references to taxonomically identified crayfishes throughout this report refer to only males. All crayfish specimens for which taxonomic identifications were questionable were forwarded to the Illinois Natural History Survey Center for Biodiversity (C. A. Taylor) for taxonomic verification.

Determining bait shop knowledge of crayfish stocks

Following the bait shop survey we conducted an additional telephone survey of the 135 Missouri bait shops that had previously indicated that they sold crayfishes to determine whether they knew what species of crayfish they sold. We surveyed only bait shop owners or managers (for consistency), and the order of calls was randomly determined. The survey was conducted from November 2006 to January 2007. Three questions were posed to each shop owner/manager: (1) "Do you ever sell crayfish or crawdads in your shop?", (2) "Do you know what type of crayfish or crawdads you sell in your shop?", and (3) "What type do you sell?". Meyer et al. (2007) provides a detailed summary of the survey script and protocols for how each telephone call outcome (e.g., unanswered call, disconnected telephone number, etc.) was addressed.

RESULTS

Survey of U.S. and Canadian fisheries agencies

We recorded a 78% (49 of 63) overall response rate to our e-mail survey of fisheries agencies; 86% among U.S. states and 46% among Canadian provinces and territories. Nearly half (49%) of those respondents indicated that they were aware of an alien freshwater crayfish problem in their state, province, or territory in which the suspected cause was bait-bucket introduction (Table 1). Most respondents (61%) reported existing regulations designed to address their alien crayfish problems (answered "yes" to some part of question 2), and an additional 29% of respondents cited existing regulations on use, sale, and transport of live bait that were not necessarily in response to identified alien crayfish problems.

We observed substantial variability in regulations governing the use, sale, and transport of crayfishes as bait. Most respondents (58%) restrict release of live crayfish bait into natural waters and 39% of respondents reported that they restrict the use of live crayfish as bait to some degree. Two respondents (4%; Alberta and Nova Scotia) prohibit the use of all live crayfishes as bait on all waters, and two additional respondents (Arkansas and Maryland) reported that they are considering a similar regulation. An additional 16% (Arizona, Idaho, Minnesota, Ontario, Utah, Virginia, Washington, and Wyoming) have eliminated the sale of live crayfishes for bait through direct prohibition or by prohibiting live transport, and another 10% (British Columbia, Minnesota, New York, Quebec, and Wisconsin) prohibit the use or possession of live crayfishes on specific waters. Seven respondents (14%; Arizona, Idaho, Minnesota, Ontario, Utah, Washington and Wyoming) permit the use of live crayfishes for bait only in the body of water from which they were captured.

Some respondents reported on non-regulation management strategies they have implemented to address alien crayfish introduction problems. These strategies included encouraging the public to catch and kill alien crayfishes (e.g., Alberta and Arizona) and educational outreach to the bait industry, pet/aquarium industry, or educators (e.g., Arizona, Mississippi and Missouri).

Survey of Missouri bait shops

Species composition of bait crayfishes.—In April 2003, we sampled 929 crayfishes (500 males, 429 females) from 32 Missouri bait vendors. The other 42 bait shops we surveyed had no crayfishes in stock. Samples included 309 (61.8%) form I and 191 (38.2%) form II males. Crayfishes from 29 shops were taxonomically identified; samples from the other three shops included only females. A total of 376 male crayfishes were identified to species, 116 additional males were identified to genus, and 8 males (1.6% of all males) were not identified due to decomposition. Two crayfish genera and six species were present in bait shop samples (Table 2). The majority (76.8%) of male crayfishes were in the genus *Orconectes* including *O. virilis*, *O. immunis*, *O. rusticus*, *O. nais* (the water nymph crayfish), and form II *Orconectes* spp. which could not be positively identified to species (Table 2). The remaining male crayfishes (21.6%) belonged to the genus *Procambarus* and included two species, *P. acutus* and *P. clarkii* (Table 2).

Crayfish samples from many bait shops contained only one species (determined from identification of male specimens only), but some shops' samples indicated that they sold multiple species (Table 3). We identified three *Orconectes* species, *O. immunis*, *O. rusticus*, and *O. nais*, that were not listed on the MAASL in April 2003 and represented illegal bait sales (Table 2). Ten shops (27.8% of shops surveyed in 2003 that had male crayfishes) sold illegal crayfish species; four of those shops sold illegal alien *O. rusticus*, one shop sold illegal alien *O. nais*, and five of the shops sold the illegal native (to Missouri) crayfish *O. immunis* (one shop sold a mixture of illegal native *O. immunis* and alien *O. rusticus*; Table 3). Our estimates of the proportion of vendors selling illegal crayfishes were conservative due to our inability to taxonomically identify female crayfishes and all form II male crayfishes.

Our visitation of 16 additional bait shops in May 2003 did not produce a higher proportion of shops with crayfishes in stock than the earlier April sampling (during each visit we collected crayfishes from 43% of shops). As expected, this later sampling also failed to produce a higher proportion of taxonomically identifiable form I males than the April sample. The May sample yielded 265 crayfishes (135 males and 130 females) from 7 shops; 8 shops had no crayfishes and 1 shop was not open. Males were present in samples from all 7 shops; but most (85.9%) were not form I males. Most (80.8%) crayfishes collected during May 2003 were *P. acutus* and an additional 0.7% were unidentifiable *Procambarus* spp. (Table 2). Three other species, *O. virilis*, *O. immunis*, and *O. nais*, and unidentifiable *Orconectes* spp. (likely *O. virilis* or *O. nais*) were present in relatively low proportions. No *O. rusticus* were present in May 2003 samples. Six of these seven shops (85.7%) sold *P. acutus* (Table 3). Three shops (42.9%) sold multiple species, but only one of seven shops (14.3%) sold illegal crayfishes (*O. immunis* and *O. nais*).

Table 2. Total crayfish, number of male crayfish, and percent of each crayfish species (male specimens only) collected from Missouri bait shops during 2003 and 2004 survey.

Collection date	Total crayfish collected	Number of male crayfish collected	*O. nais* (%)	*O. rusticus* (%)	*O. immunis* (%)	*O. virilis* (%)	*P. acutus* (%)	*P. clarkii* (%)	[a]Unknown *Orconectes* spp. (%)	[a]Unknown *Procambarus* spp. (%)
April 2003	929	500[b]	1.0	15.4	19.4	17.8	20.2	1.4	23.2	0.0
May 2003	265	135	0.7	0.0	0.7	4.5	80.8	0.0	12.6	0.7
April 2004	1196	666	0.0	0.0	14.6	24.5	42.8	6.6	10.1	1.4

[a] Unknown *Orconectes* spp. or *Procambarus* spp. are form II male specimens for which species identification could not be confirmed.
[b] Eight male crayfish (1.6%) collected on 4/4/2003 were not identified due to decomposition

Table 3. Percent of Missouri bait shops visited during survey that were selling male specimens of various crayfish species. Cumulative percentages (species added together) are greater than 100% due to multiple species being sold at individual shops. Bold font indicates crayfish species that were classified as illegal during a given year.

Collection date	Number of shops with male crayfish	***O. nais*** (%)	***O. rusticus*** (%)	***O. immunis*** (%)	*O. virilis* (%)	*P. acutus* (%)	*P. clarkii* (%)	[a]Unknown *Orconectes* spp. (%)	[a]Unknown *Procambarus* spp. (%)	Shops selling >1 species (%)
April 2003	29	3.4	13.8	17.2	31.0	34.5	3.4	34.5	0.0	10.3
May 2003	7	14.3	0.0	14.3	14.3	85.7	0.0	42.9	14.3	42.9
April 2004	36	0.0	0.0	13.9	27.8	63.9	11.1	22.2	8.3	22.2

[a]Unknown *Orconectes* spp. or *Procambarus* spp. are form II male specimens for which species identification could not be confirmed.

In April 2004, we sampled 1,196 crayfishes (666 males and 530 females) from 36 of the 98 surveyed bait shops. Forty-five other shops had no crayfishes and the remaining 17 shops were closed or out of business. Proportions of form I (47.4%) and form II (52.6%) males were similar. Male crayfishes identifiable to species were collected from 35 shops and the remaining shop sample contained male crayfishes identifiable only to genus. *Procambarus* species constituted 50.8% of sampled crayfishes, and *P. acutus* were more abundant than *P. clarkii* (Table 2). *Orconectes* species including O. *virilis* and O. *immunis* composed 39.1% of sampled crayfishes; an additional 10.1% of sampled crayfishes were unidentifiable *Orconectes* spp. (Table 2). No illegal species were identified in 2004 samples (*O. immunis* was added to the MAASL in March 2004); however, one bait vendor indicated that he expected a shipment of O. *rusticus* later in the fishing season from a wholesaler in Wisconsin. At least eight shops (22.2%) surveyed in 2004 sold multiple crayfish species (Table 3).

Comparison of bait shop locations to historical distributions of crayfishes.—Crayfish samples from bait shops across Missouri indicated that at least four species were being sold at shops outside of the species' known historical geographic distribution. Bait shops selling illegal O. *rusticus* in 2003 were located at four locations in central and eastern Missouri, and illegal O. *nais* were sold at two shops in the western and north-central portions of the state (Figure 3). The majority of shops selling *P. clarkii* and *P. acutus* were located outside of the known historical range of these species (Figures 4 and 5). All bait shops selling *P. clarkii* and *P. acutus* in April and May 2003 were located outside of the known historical range of these species. In 2004, all surveyed shops selling *P. clarkii* and 96% of shops selling *P. acutus* were located outside of the species' known historical distribution. Most bait shops selling O. *immunis* and all shops selling O. *virilis* were located within each species' known range (Figures 6 and 7).

Bait crayfish sources and records inspection.—Inspection of bait shop receipts to determine sources of crayfish stocks revealed that two (6.3%) and seven (19.4%) surveyed shops in 2003 and 2004, respectively, could not produce legal records. Two of these shops (one shop from each of 2003 and 2004) claimed that the crayfish were "bycatch" that accompanied shipments of bait fish, but these shops were also unable to produce legal receipts for the bait fish. Records from the remaining shops indicated that

Figure 3. Location of bait shops where *Orconectes rusticus* and *Orconectes nais* were collected in 2003.

Figure 4. Historical distribution of *Procambarus acutus* in Missouri and locations of bait shops where *P. acutus* were collected in 2003 and 2004. The two historical locations in north-central Missouri are believed to be introduced populations (William Pflieger, MDC retired, pers. comm.).

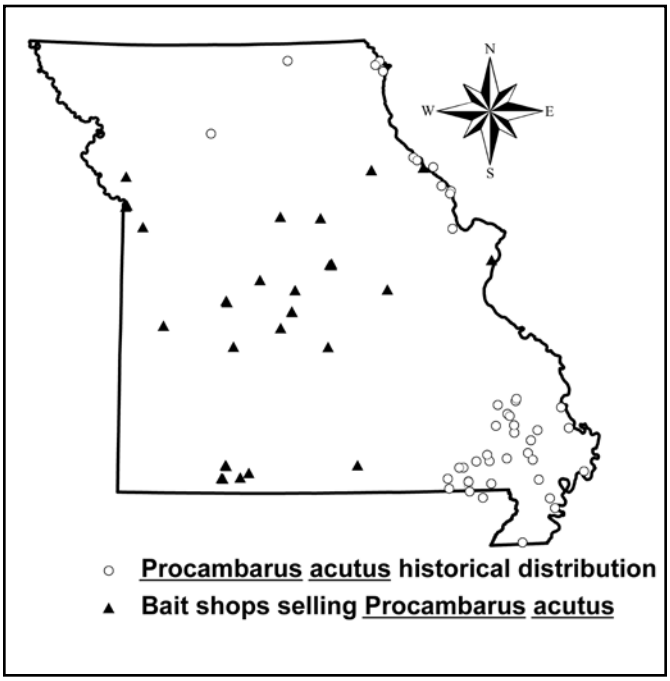


Figure 5. Historical distribution of *Procambarus clarkii* in Missouri and locations of bait shops where *P. clarkii* were collected in 2003 and 2004.

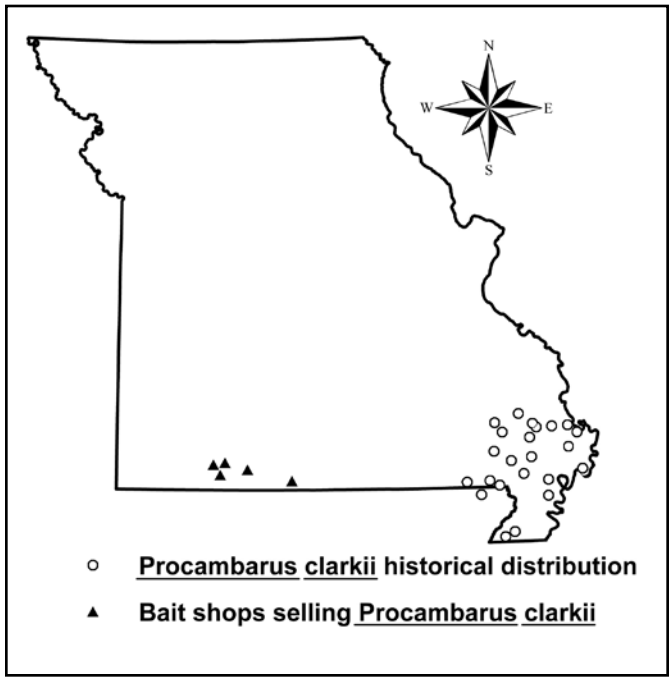


Figure 6. Historical distribution of *Orconectes immunis* in Missouri and locations of bait shops where *O. immunis* were collected in 2003 and 2004.

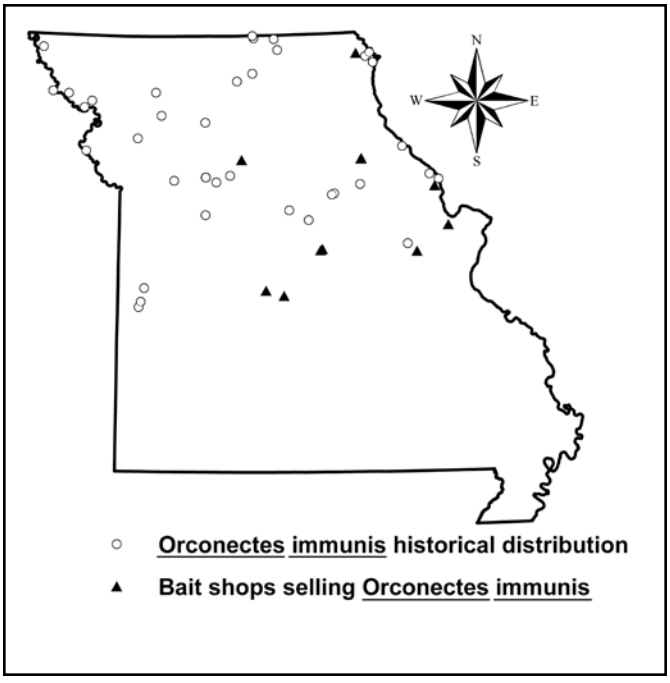
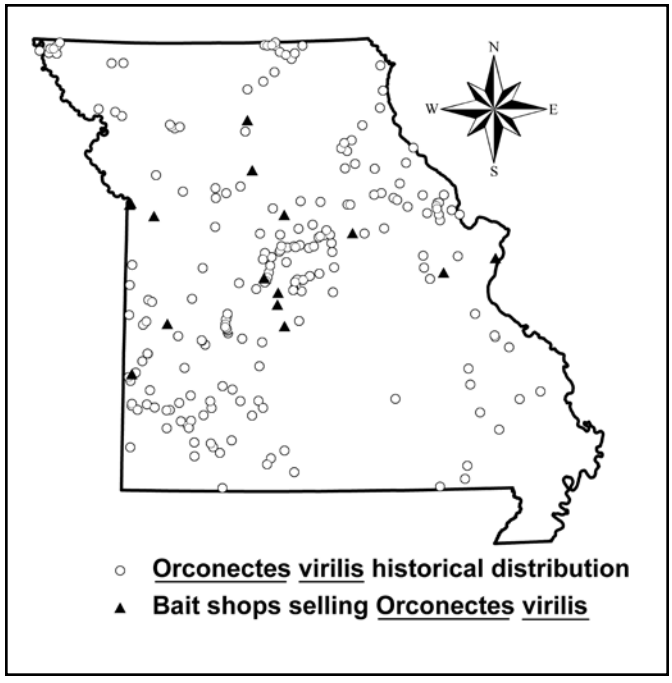


Figure 7. Historical distribution of *Orconectes virilis* in Missouri and locations of bait shops where *O. virilis* were collected in 2003 and 2004.



crayfish stocks were obtained from 20 individual sources from four states in 2003 (Missouri [*n* = 15 sources], Arkansas [*n* = 3], Illinois [*n* = 1], Kansas [*n* = 1]) and 19 sources from five states in 2004 (Missouri [*n* = 12], Arkansas [*n* = 3], Oklahoma [*n* = 1], Nebraska [*n* = 1], Wisconsin [*n* = 1]). Eight sources of *P. acutus* and one source of *P. clarkii* were located in Missouri but outside of the known historical range of the species being cultured. The four shops selling *O. rusticus* in April 2003 were supplied by two sources in Missouri that had originally obtained rusty crayfish from a vendor in Wisconsin. During receipt inspections, one shop indicated that their crayfishes were sometimes collected (illegally) from the wild at a city park, and another shop admitted that their

crayfishes were supplied (illegally) by local children from a nearby creek. One bait shop supplied their own crayfishes from a private pond on their property.

Determining bait shop knowledge of crayfish stocks

Fifty-one percent of the 135 bait shops that we telephoned in 2007 were contacted and agreed to participate in the telephone survey, and only 3 bait shop owners refused to participate. We were unable to contact 47% of the shops.

Thirty-eight (55%) of the 69 shop owners/managers who participated in the telephone survey indicated that they sold crayfishes. Most (87%) of those shops admitted that they did not know what type (species) of crayfish they sold; only 5 bait shops (13%) claimed to know what they sold. However, 4 of the shop owners/managers who claimed to know what species they sold provided crayfish names that were not recognized common names (see Williams et al. 1988; Pflieger 1996; Taylor et al. 2007) for any species in Missouri. Only 1 (2.6%) of 38 survey respondents provided a correct common name for the crayfish species that he sold.

DISCUSSION

Lodge et al. (2000b) recently advised all U.S. states to ban the use of live crayfishes as bait. Our 2008 survey of all 50 U.S. states, 10 Canadian provinces, and 3 Canadian territories revealed that nearly half of responding agencies were aware of aquatic resource problems believed to be caused by bait-bucket introductions of alien crayfishes, and these agencies reported a wide range of regulations designed to address such problems. Despite these threats, only 4% of responding agencies had prohibited the use of live crayfishes as bait on all waters. However, at least two states (J. Kilian, Maryland Department of Natural Resources, pers. comm.; B. Wagner, Arkansas Game and Fish Commission, pers. comm.) have recently proposed such a regulation. Many agencies responding to our survey reported regulations restricting the use (39% of respondents) and/or sale (37%) of crayfishes as bait (Table 1), but had not enacted a total ban. Several respondents addressed the problem by banning sale or transport of live crayfish. The observed inconsistency in regulations among states, provinces, and territories may also contribute to the problem of alien crayfish introductions (Peters and Lodge 2009).

Our 2002–2007 evaluation indicated that Missouri bait shops are a potential source for the introduction of alien and possibly invasive crayfishes to Missouri's waters. Although we did not specifically document the transfer of crayfishes sold in Missouri bait shops to their release into natural water bodies in Missouri, it is a logical assumption that some of the crayfishes that had been sold would be released into the wild. Previous studies indicated that angler release of bait is common and thus a vector for bait organism introductions (Litvak and Mandrak 1993; Keller et al. 2007) and that anglers transfer bait across drainage basins (Litvak and Mandrak 1993; Ludwig and Leitch 1996). Burkholder and Wallace (2001) documented occurrence of introduced rusty crayfish both in bait shops (illegally) and in nearby streams in one Pennsylvania county. Due to varying levels of supply and demand, the species sold and sources of crayfish stock are likely to change throughout seasons and years. Our collections of crayfishes from bait shops were conducted during only 1–3 days per sampling year, providing a brief point-in-time evaluation of the species composition of bait stocks. In addition, we did not attempt to identify female crayfishes to species, so this study provides a conservative estimate of the number of bait shops selling illegal and/or alien species. Despite these limitations, our study revealed important findings about the potential for crayfish introductions via the bait industry. We documented the presence of three illegal species (not listed on the MAASL), including the first documentation of rusty crayfish at Missouri bait shops. To date, the state of Missouri has not documented rusty crayfish in state waters, but no specific investigations have been conducted. We also documented the sale of legal crayfish species (currently approved for sale by the MAASL) at bait shops located in multiple watersheds outside of the species' known historical range. In particular, *P. acutus*, native to only southeast Missouri and portions of the main-stem Mississippi River, was found at many bait shops throughout the state. Following completion of this study, we have documented the presence of *P. acutus* in the wild at four separate localities in Missouri that are well outside of this species' native distribution (R. J. DiStefano, MDC, unpublished data). The effects of introduced *P. acutus* on native biodiversity, habitat, and fish populations in these areas are unknown, but monitoring and evaluating these effects should be considered due to numerous documented impacts of a similar species, *P. clarkii*, in other aquatic ecosystems (Gherardi and Acquistapace 2007; Hobbs et al. 1989).

In addition, our study highlighted specific characteristics of the bait industry that may complicate agencies' abilities to regulate crayfish sales or prevent introductions of alien species:

- The bait industry is dynamic and subject to frequent change. Many telephone contact numbers for shops were disconnected or shops were no longer in business. Some shops surveyed via telephone in the autumn of 2002 were no longer in business by the spring of 2003 or 2004. Additionally, new shops opened during the course of our study.
- Bait vendors may not comply with regulations regarding species being sold. At least 27% (10 of 36) of shops selling crayfishes in 2003 sold illegal crayfish species. It is likely that illegal species periodically exist in Missouri bait vendor stocks.
- Many bait vendors obtain crayfishes from many out-of-state sources and occasionally as bycatch with bait fish orders, and some do not retain written documentation of sources. Also, some bait vendors are illegally obtaining crayfishes from wild populations. The importation of crayfishes from out-of-state and the illegal sale of wild crayfishes complicate the ability of state and provincial agencies to regulate crayfish supplies.
- Most bait vendors do not know what species they are selling. Our 2007 telephone survey revealed that 87% of bait shop proprietors readily admitted to not knowing (in fact, 97% did not know) what species they were selling (Meyer et al. 2007).

Although our study evaluated crayfish bait sales in only one U.S. state, these observations are likely applicable to the bait industry in other U.S. states and Canadian provinces and territories. Problems associated with aquatic invasive species are widespread throughout North America, and many organisms, such as Asian carp species and zebra mussels, have recently received much attention by fisheries agencies. The U.S. Aquatic

Education of bait dealers accompanied by a stronger focus on regulation and enforcement is essential to reducing the introduction of invasive crayfishes. Ninety-seven percent of bait shop managers were unable to name the crayfish species they sold.

Nuisance Species Task Force 2007–2012 Strategic Plan (U.S. ANS Task Force 2007) identifies two main objectives as "identify priority pathways for the introduction of harmful aquatic species into waters of the United States and coordinate specific actions to reduce the likelihood of introduction of harmful nonindigneous aquatic species via these pathways" (Objective 1.2, ANS Task Force 2007) and "investigate the feasibility and mechanisms for interdicting, interrupting, or minimizing priority pathways" (Objective 1.3, U.S. ANS Task Force 2007). This study indicated for crayfish bait what previous studies (Litvak and Mandrak 1993; LoVullo and Stauffer 1993; Ludwig and Leitch 1996; Kircheis 1998; Keller et al. 2007) have indicated for bait fishes and earthworms; the bait industry and bait-bucket introductions by anglers may be significant pathways for the introduction of alien and invasive species. Additionally, we suggest that current management approaches (regulation, enforcement, education) by many agencies relative to the sale and use of crayfish bait do not address some characteristics we documented for Missouri's bait industry (listed above) that may contribute to the introduction and spread of alien species.

Some respondents to our e-mail survey (Indiana, Iowa, and New York) were aware of established alien crayfish populations, but had not documented problems caused by those introductions. However, there is documentation for other states that have experienced adverse effects of crayfish introductions of those introduced species (such as hybridization with native species) that were historically sold in bait shops within their states (J. Wallace, Millersville University, Pennsylvania, pers. comm.; M. Demlong, Arizona Game and Fish Department, pers. comm.). In addition to regulating the bait industry, some states reported regulations or concerns associated with the pet/aquarium industry (Missouri, Virginia, and Washington) or school science classes (Arizona, Missouri, and Washington; see Larson and Olden 2008). Several respondents (e.g., Georgia, Iowa, Missouri, Saskatchewan, Virginia, and Washington) also prohibit import or export of some or all live crayfish species; often these are species classified as "aquatic nuisance species."

Previous studies suggested that fishery agency on-site surveys of or contacts with bait stores may help reduce a lack of awareness of bait regulations by anglers, and a lack of compliance with bait regulations by bait shops, while providing an opportunity to educate store owners and anglers. A survey of Toronto, Ontario, bait shops found that more than half of surveyed anglers were unaware of regulations prohibiting the release of live bait (Litvak and Mandrak 1993). On-site inspections by the Maine Department of Inland Fisheries and Wildlife staff reduced the

incidence of illegal species in bait shop stocks and were used as a mechanism to facilitate working relationships with bait shops (Kircheis 1998). Following our bait shop surveys, MDC has attempted to reduce the introduction and spread of aquatic invasive species through public education efforts and increased communication and partnerships with bait shops (Dent 2006). Beginning in 2007, all bait vendors were required to register with MDC to provide annually updated contact information for dissemination of information and educational literature. Bait vendors were provided with posters and bait-bucket stickers informing anglers that it is illegal to release bait into the wild. The MDC and Illinois Natural History Survey also created a brochure (DiStefano et al. 2008b) to aid bait vendors in identification of legal and illegal invasive crayfish species. Although most bait shops expressed interest in participating in educational programs (Dent 2006), additional efforts are needed to deter the introduction of invasive crayfishes. It should be noted that MDC has not yet evaluated educational efforts intended to reduce alien species introductions or spread. We concur with Lodge et al. (2000b) that all states, provinces, and territories should review their existing regulations and consider a ban on the use of live crayfishes as bait. If such a ban is deemed not feasible or not practical, agencies should consider one or more of these alternatives: (1) restrict use to only preserved crayfish bait which would simplify enforcement and prevent disease transmission (Litvak and Mandrak 1993), (2) restrict use to only those crayfish captured by anglers at the water body where they fish, (3) restrict bait sales and use to limited and safer species, e.g., use of only ubiquitous species or species with minimal chance of surviving bait-bucket introduction; (Litvak and Mandrak 1993), (4) restrict the import of crayfish bait from outside state or provincial boundaries (e.g., Ontario, Saskatchewan), (5) restrict the use of live crayfish bait to only specific water bodies (e.g., British Columbia, New York, Quebec), and (6) cooperate with agencies from bordering jurisdictions on regulations to prevent introductions in watersheds shared by states, provinces, or territories.

With 75% of the world's crayfish diversity inhabiting the North American continent (Taylor et al. 2007), U.S. and Canadian fisheries agencies should strive to conserve native crayfish populations, not only to preserve diversity, but also to maintain the important ecological role that crayfishes perform. Evidence suggests that management practices to reduce the potential for bait-bucket introductions of alien crayfishes would be a significant step in the conservation of those native crayfish populations. Such management practices might also reduce potential adverse effects to ecological functioning of aquatic systems, help sustain fisheries and other native fauna and flora, and prevent substantial economic damage. The combination of our e-mail survey of U.S. state and Canadian provincial and territorial fisheries agencies and an intensive examination of Missouri's bait industry lead us to conclude that traditional approaches to crayfish bait regulation, regulation enforcement, and management have not adequately protected aquatic ecosystems in Missouri and on this continent. State, provincial, and territorial fisheries agencies would be more successful by combining angler education with more focused regulation (and accompanying enforcement) on the sale and use of crayfishes as bait (Litvak and Mandrak 1993; Keller et al. 2007) or by enacting a ban on live crayfish bait as suggested by Lodge et al. (2000b).

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FEATURE:
PROFESSIONAL ISSUES

Maintaining the Competitiveness of the American Fisheries Society Journals: An Assessment Based on Influence and Cost-Effectiveness

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ABSTRACT: Recent changes in the landscape of scientific publishing prompted the Publications Overview Committee of the American Fisheries Society (AFS) to review the Society's portfolio of scientific journals. We evaluated journals based on metrics in two categories: (1) citation-based measures of the influence of a journal on the scientific literature, and (2) measures of the cost-effectiveness of a journal (citation rate adjusted for subscription cost). Over the long-term, we found that ecology journals had far stronger citation-based influence than fisheries and aquatic sciences journals, and that journals publishing primarily basic research had stronger influence than journals publishing applied research (including four AFS journals and *Fisheries* magazine). In evaluating the current status of fisheries and aquatic sciences journals, we found that metrics of influence and cost-effectiveness provided considerably different portrayals of journals relative to their peers. In terms of citation-based influence, we found that the AFS journal *Transactions of the American Fisheries Society* (*TAFS*) and *Fisheries* magazine were competitive with highly regarded peer fisheries journals, but that *North American Journal of Aquaculture* (*NAJA*) and *Journal of Aquatic Animal Health* (*JAAH*) were less influential than their peers. The citation-based influence of *North American Journal of Fisheries Management* (*NAJFM*) was intermediate between *TAFS*/*Fisheries* and *NAJA*/*JAAH*. For journals like *NAJFM* and *NAJA*, we expect that much of the scientific influence on policy and management is not captured by citations in the primary literature, and alternative methods of evaluation may be needed. All of the AFS journals ranked highly with regard to cost-effectiveness because their subscription costs are low, and these rankings are in accordance with membership needs and the strategic mission of AFS to provide broad and timely dissemination of scientific information. We conclude by suggesting ways to increase the influence of AFS journals without compromising their accessibility and affordability, and offer advice about methods and frequency for future journal evaluations.

Mantenimiento de la competitividad de las revistas de la Sociedad Americana de Pesquerías: una evaluación basada en la influencia y efectividad de costos

RESUMEN: Los recientes cambios en materia de publicación científica alertaron al Comité de Revisión de Publicaciones de la Sociedad Americana de Pesquerías (SAP) a evaluar el cuadro de revistas de esta sociedad. Se evaluaron las revistas sobre la base de dos criterios: (1) medidas basadas en las citas acerca de la influencia de una revista en la literatura científica, y (2) medidas relativas a la efectividad de los costos de una revista (tasa de citas ajustada por el costo de suscripción). En el largo plazo, se encontró que las revistas de ecología tuvieron, por mucho, una mayor influencia en cuanto a número de citas que aquellas revistas de ciencias acuáticas y pesquerías; y que las revistas que publican artículos de investigación básica tuvieron mayor influencia que las que publican artículos de ciencia aplicada (incluyendo cuatro revistas de la SAP y la revista *Fisheries*). Al evaluar el estado actual de las revistas de pesquerías y ciencias acuáticas, se encontró que la métrica referente a la influencia y efectividad de costos muestra panoramas completamente diferentes de las revistas en comparación con sus pares. En términos de la influencia basada en el número de citas, notamos que dos revistas de la SAP *Transactions of the American Fisheries Society* (*TAFS*) y *Fisheries* tuvieron un importante nivel de competitividad en relación a revistas similares de pesquerías consideradas de alto nivel, pero también descubrimos que las revistas *North American Journal of Aquaculture* (*NAJA*) y *Journal of Aquatic Animal Health* (*JAAH*) tuvieron menos influencia que sus pares. La influencia de acuerdo al número de citas de la revista *North American Journal of Fisheries Management* (*NAJFM*) se colocó en un lugar intermedio entre *TAFS*/*Fisheries* y *NAJA*/*JAAH*. Para revistas como *NAJFM* y *NAJA*, esperamos que una gran parte de la influencia científica sobre política y el manejo, no es captada en la literatura, y por lo tanto pueden requerirse métodos alternativos de evaluación. Todas las revistas de la SAP obtuvieron una puntuación alta en cuanto a efectividad de costos ya que el monto de las suscripciones es bajo, y estos rankings son congruentes tanto con las necesidades de las membresías de cada revista como con la misión estratégica de la SAP en lo tocante a la difusión amplia y oportuna de información científica. Como conclusión, sugerimos algunas formas para incrementar la influencia de las revistas de la AFS sin comprometer su accesibilidad, en lo logístico y económico, y ofrecemos una guía sobre métodos y frecuencia para futuras evaluaciones de revistas.

INTRODUCTION

Publishers must continuously adapt to philosophical and technological changes in the expanding, dynamic marketplace of scientific information. As examples, the rise of open access publishing models and the electronic distribution of articles have rapidly and substantially altered the playing field (Bergstrom and Bergstrom 2006; Eysenbach 2006; Evans 2008; Taylor et al. 2008; Evans and Reimer 2009). In particular, professional societies and university presses must evaluate and adapt their practices in order to remain competitive with large commercial publishers, and competition has only become more acute with the recent profusion of journals (e.g., Kareiva and Yuan-Farrell 2006; Mather et al. 2008). The American Fisheries Society (AFS) recognized the need for change during the recent development of its new open access, online-only journal *Marine and Coastal Fisheries* (Eells 2006; Kohler 2006; DeVries et al. 2007; Rassam 2007; Fabrizio 2008). In addition to helping maintain relevant and competitive products, regular evaluations of journals provide a service to members of a scientific society by assisting them (as authors, reviewers, or editors) in their choices about and expectations for dissemination of scientific information.

As part of a continuing effort to evaluate and improve the scientific information products and services of AFS, the Publications Overview Committee conducted an assessment of the Society's multidisciplinary portfolio of journals. We evaluated all of the extant journals, namely *Transactions of the American Fisheries Society* (*TAFS*), *North American Journal of Fisheries Management* (*NAJFM*), *North American Journal of Aquaculture* (*NAJA*), and *Journal of Aquatic Animal Health* (*JAAH*), as well as *Fisheries* magazine, which is currently treated much like a journal. Our assessment builds on a prior analysis of co-citation patterns in fisheries and aquatic sciences (F&AS) journals that illustrated the broader interdisciplinary context in which the AFS journals function (McCain 1994).

Any evaluation of journal success depends on the criteria used to judge whether a journal has achieved its stated goals and objectives. Thus, success can mean different things for different journals. The measurement of journal influence within bibliometry has received increasing attention in recent decades and a variety of metrics are now available. We recognize that no single influence metric is without flaw, and citation-based influence may not be the only criterion to consider (Monastersky 2005; Garfield 2006; Bergstrom 2007; Lawrence 2007; Wilson 2007; Lovegrove and Johnson 2008; Taylor et al. 2008). We sought to provide a concise yet informative evaluation of the AFS journals by including two citation-based metrics of influence as well as relatively new measures of cost-effectiveness, or value. Our assessment included the familiar and long-standing Impact Factor (IF), metrics from the Eigenfactor project (EF, PPEF; www.eigenfactor.org), and the Relative Price Index (RPI; www.journalprices.com), which measures the cost-effectiveness of a journal as its influence adjusted for subscription cost (Box 1). Higher values of influence metrics indicate that journals are cited more often on average than their peers, whereas lower RPI scores indicate better relative cost-effectiveness.

We compared the AFS journals to their peers in F&AS, and also compared the AFS and other F&AS journals to classic ecology journals to provide context for our assessment. The objectives of our work were fourfold. First, we wanted to inform the AFS membership about various metrics used to evaluate journal success, as well as their advantages and disadvantages. Second, using Impact Factors, we wanted to compare long-term trends in influence for the AFS

Box 1. Descriptions of the four quantitative metrics used in our analysis of the American Fisheries Society journals and their peers. All data was accessed on 4 February 2009.

Metrics of journal influence (bigger is better)

1. Impact Factor (IF)
   - Taken from Thomson Reuters Scientific (ISI Web of Knowledge) Journal Citation Reports (JCRs)
   - Uses a 2-year window for tracking citations (JCRs now also report 5-year IFs, but our analysis used 2-year IFs)
   - Measures per-article influence of a journal based on citations from journals indexed by ISI, including citations from other journals as well as citations from within the same journal
   - All citations are considered equal
   - See www.thomsonreuters.com/products_services/scientific/Journal_Citation_Reports for more details
2. Eigenfactor (EF)
   - Taken from the Eigenfactor project
   - Uses a 5-year window for tracking citations
   - Measures total influence of a journal on the scientific literature based on citations from other journals, ignoring same-journal citations; uses the ISI JCR citation data
   - All citations are not considered equal; citation network for each journal is used to value citations depending on where they originate within the journal's network, similar to Google's PageRank algorithm
   - See www.eigenfactor.org for more details

Metrics of journal cost-effectiveness (smaller is better)

1. Price per Eigenfactor (PPEF)
   - Taken from the Eigenfactor project
   - Includes citation data through 2006 and journal subscription prices for 2008 (prices taken from Journal Cost-Effectiveness project; see below)
   - Calculated for each journal as EF (left) divided by subscription price
2. Relative Price Index (RPI)
   - Taken from the Journal Cost-Effectiveness project
   - Includes citation data through 2006 and journal subscription prices for 2008
   - Calculated for each journal using a combination of subscription price, number of articles published, and a recent citation rate based on ISI JCR citation data
   - Compares the cost-effectiveness of a journal to the median cost-effectiveness of non-profit (cheaper) journals in the same JCR subject category
   - Journals are subjectively categorized as to their value based on the following criteria: RPI < 1.25 = High Value; 1.25 ≤ RPI < 2.5 = Medium Value; RPI ≥ 2.5 = Low Value
   - See www.journalprices.com for more details, particularly information on how journal subscription prices were determined

journals with other F&AS and ecology journals. Third, we wanted to explore the relationship among metrics of influence and cost-effectiveness and compare what the metrics indicate about the current status of the AFS journals relative to their peers. Lastly, we developed suggestions for strategic changes in publishing practices that may be worthy of consideration to make the AFS journals more effective and influential in communicating science to the global fisheries community.

METHODS

In compiling a list of F&AS journals, we used two primary sources as guides: (1) the list of journals included in the Fisheries category of the 2007 Science edition of the ISI Web of Knowledge Journal Citation Report (JCR; Thomson Reuters Scientific), and (2) the list of journals included in the previous analysis by McCain (1994). We also included and excluded some journals based on our own collective judgment, and we attempted to provide a balance between journals that covered marine and freshwater ecosystems. Our list is intended to be representative rather than exhaustive, and the selection process is prone to subjectivity because of the interdisciplinary nature of the F&AS literature (McCain 1994). For example, Mather et al. (2008) included fish-related journals that had been assigned to seven different categories in the JCR. We included 22 of the 40 journals in the JCR Fisheries category for 2007, 18 of the 43 journals identified by McCain (1994; 10 of which were not included in the JCR Fisheries category), and 4 other journals we felt were important to include. In sum, 36 F&AS journals were included in the assessment (Table 1). We also included 10 well-known ecology journals that we felt provided a representative set for comparisons with the F&AS literature (Table 1).

By consensus and generally in accordance with published journal descriptions, we categorized each of the F&AS journals with regard to their subdiscipline (disease, aquaculture, general fisheries, general aquatic sciences) and the primary type of research that they publish (basic or applied). We included all aquatic disease and aquaculture journals, as well as most general fisheries journals, in the applied research category. However, we recognize that most journals fall on a continuum between basic and applied research and other judgments are possible. For the journals included in McCain (1994), we followed the results of her citation analysis in categorizing journals as general fisheries or general aquatic sciences. For journals not included in McCain (1994), we categorized journals based on our consensus judgment. We also included the profit status (for-profit or non-profit) of each of the journals from a web site dedicated to providing information on the economics of scholarly journals (www.journalprices.com).

To evaluate journal influence, we used the familiar per article influence metric Impact Factor (IF; Garfield 1955, 2006) from the JCRs and Eigenfactor (EF) scores from the Eigenfactor project. We also examined the separate per article influence metric from the Eigenfactor project (known as Article Influence, or AI), but found that it was highly correlated with Impact Factor ($r > 0.95$). Although AI provides different information than IF because of different methodology, we excluded AI from our evaluation for simplicity of presentation. Essentially, journals are considered relatively more influential if they publish articles that are cited more often on average than articles in other peer journals. Both IF and EF are intended to measure the relative influence of journals, but rather than measuring per article-influence like IF, EF measures the total influence of a journal on the scientific literature. Calculations of EF differ from calculations of IF in two important ways (see Box 1).

To explore long-term trends in journal influence, we plotted the average annual IF from 1975 to 2007 for three comparisons: (1) journals that publish primarily applied research versus those that publish primarily basic research, (2) the AFS journals versus a comparable set of other F&AS journals and a set of ecology journals, and (3) *TAFS* versus a set of four peer applied fisheries journals. The number of journals included in group averages usually increased over time because not all journals were indexed by ISI back to 1975, and some were newly established during the period. We excluded journals that were indexed for only a short portion of the time period, such as *Fisheries Management and Ecology* (first indexed by ISI in 1999).

To evaluate journal cost-effectiveness, we included derived calculations from the Journal Cost-Effectiveness project and the Eigenfactor project (Box 1). Essentially, cost-effectiveness is calculated by adjusting the cost of a subscription with an influence metric (e.g., Price per Eigenfactor, or PPEF). Lower scores indicate that journals receive more citations per unit cost and are thus relatively more cost-effective.

We provide a more complete comparison of four specific subsets of journals: (1) aquaculture journals, (2) disease journals, (3) fisheries review journals, and (4) journals we considered to be peers of *TAFS*, *NAJFM*, and *Fisheries* (hereafter, the AFS general fisheries journals). These subsets of journals were separated to provide a fairer comparison among direct peers. In all comparisons, we included both influence and cost-effectiveness metrics. We based our evaluations of influence on means across the last three years (IF: 2005–2007; EF: 2004–2006) and report the most recent measures of cost-effectiveness (PPEF and RPI). The subsets for aquaculture and disease journals included two peer journals for the AFS journal in each subset. We included 27 journals in the subset we considered to be peers of the AFS general fisheries journals. For this subset, we also performed a principal components analysis using the most recent data for influence and cost-effectiveness metrics (IF [2007]; EF, PPEF, and RPI [2006]) to illustrate the difference in perspective provided by the two types of metrics.

RESULTS

Long-term trends in average Impact Factor showed that journals that publish applied research had lower influence than basic research journals through the 1980s, but are increasing in parallel with basic research journals in recent years (Figure 1). A comparison of the average IF for the AFS journals with average IFs for groups of ecology and F&AS journals indicated that the AFS journals had far lower influence than general ecology journals and somewhat lower influence than other F&AS journals (Figure 2). The average IF for all three groups has risen over the last decade or so, but the increase in IF for ecology journals has far surpassed that of F&AS journals. A comparison of the longest-standing AFS journal, *TAFS*, with four peer applied fisheries journals that we deemed to be similar showed that *TAFS* was competitive in terms of influence throughout the time series (Figure 3). Note that the time series for *TAFS* illustrates a related point—snapshot comparisons among journals, like those we make here, must be interpreted with some caution. Most journals experience year-to-year variation in influence metrics (e.g., 0.1–0.2 IF for *TAFS*) that can be as large as differences among journals, especially for IF given the shorter window for tracking citations.

Table 1. The list of journals included in our evaluation, with categorizations by five factors: (1) whether they were included in the Fisheries category of the 2007 Science edition of the ISI Web of Knowledge Journal Citation Report (JCR), (2) whether they were included in the citation analysis by McCain (1994), (3) subdiscipline (aquaculture, disease, general fisheries, general aquatic sciences, or ecology), (4) type of research (basic or applied) [review journals indicated separately], and (5) profit status (For-profit or Non-profit). American Fisheries Society journals are highlighted in yellow.

Journal title	2007 JCR Fisheries	McCain (1994)	Subdiscipline	Basic/Applied	Profit status
Fisheries and Aquatic Sciences Journals					
Aquaculture	Yes	Yes	Aquaculture	Applied	For
Journal of the World Aquaculture Society	Yes		Aquaculture	Applied	Non
North American Journal of Aquaculture[1]	Yes	Yes	Aquaculture	Applied	Non
Diseases of Aquatic Organisms	Yes		Disease	Applied	For
Journal of Aquatic Animal Health	Yes		Disease	Applied	Non
Journal of Fish Diseases	Yes	Yes	Disease	Applied	For
Bulletin of Marine Science[2]			GenFish	Basic	Non
Canadian Journal of Fisheries and Aquatic Sciences[3]	Yes	Yes	GenFish	Applied	Non
Copeia		Yes	GenFish	Basic	Non
Ecology of Freshwater Fish	Yes		GenFish	Basic	For
Environmental Biology of Fishes		Yes	GenFish	Basic	For
Fish and Fisheries	Yes		GenFish	Review	For
Fisheries Oceanography	Yes		GenFish	Basic	For
Fisheries Research	Yes		GenFish	Applied	For
Fisheries	Yes		GenFish	Applied	Non
Fisheries Management and Ecology	Yes		GenFish	Applied	For
Fishery Bulletin	Yes	Yes	GenFish	Applied	Non
ICES Journal of Marine Science[4]	Yes		GenFish	Applied	Non
Journal of Applied Ichthyology[5]	Yes		GenFish	Applied	For
Journal of Fish Biology	Yes	Yes	GenFish	Applied	For
North American Journal of Fisheries Management	Yes	Yes	GenFish	Applied	Non
Reviews in Fish Biology and Fisheries	Yes		GenFish	Review	For
Reviews in Fisheries Science	Yes		GenFish	Review	For
River Research and Applications[6]			GenFish	Applied	For
Transactions of the American Fisheries Society	Yes	Yes	GenFish	Applied	Non
Aquatic Conservation: Marine and Freshwater Ecosystems			GenAquat	Applied	For
Estuaries and Coasts[7]		Yes	GenAquat	Applied	Non
Estuarine Coastal and Shelf Science[8]		Yes	GenAquat	Basic	For
Freshwater Biology		Yes	GenAquat	Basic	For
Hydrobiologia		Yes	GenAquat	Basic	For
Journal of Experimental Marine Biology and Ecology		Yes	GenAquat	Basic	For
Journal of Freshwater Ecology			GenAquat	Basic	For
Limnology and Oceanography		Yes	GenAquat	Basic	Non
Marine and Freshwater Research	Yes		GenAquat	Basic	Non
Marine Biology		Yes	GenAquat	Basic	For
Marine Ecology Progress Series		Yes	GenAquat	Basic	For
Ecology Journals					
Biological Conservation			Ecology	Applied	For
Conservation Biology			Ecology	Applied	Non
Ecological Applications			Ecology	Applied	Non
Ecology			Ecology	Basic	Non
Ecology Letters			Ecology	Basic	For
Frontiers in Ecology and the Environment			Ecology	Applied	Non
Journal of Applied Ecology			Ecology	Applied	Non
Oecologia			Ecology	Basic	For
Oikos			Ecology	Basic	Non
Trends in Ecology and Evolution			Ecology	Basic	For

1 Published as *The Progressive Fish-Culturist* prior to 1999
2 Published as *Bulletin of Marine Science of the Gulf and Caribbean* prior to 1965
3 Published as *Journal of the Fisheries Research Board of Canada* prior to 1980
4 Published as *Journal du Conseil int. Explor. Mer* until mid-1991
5 Published as *Z. angew. Ichthyol.* prior to 1986
6 Published as *Regulated Rivers: Research and Management* prior to 2002
7 Published as *Estuaries* prior to 2006 and *Chesapeake Science* prior to 1978
8 Published as *Estuarine and Coastal Marine Science* prior to 1981

Comparisons of influence and cost-effectiveness metrics for the aquaculture, disease, and fisheries review journals showed that the metrics provided contrasting rankings (Table 2). Among aquaculture journals, the AFS journal *NAJA* is the least influential but ranks best in terms of cost-effectiveness. The same is true for *JAAH* among the disease journals, and we note that trends in both influence metrics for *JAAH* have been declining in recent years. The disease journal subset also illustrates that IF and EF can provide different interpretations about journal influence. For the most recent years, *Diseases of Aquatic Organisms* ranked highest in terms of EF but ranks behind *Journal of Fish Diseases* in terms of IF. Among the three fisheries review journals, the relatively new journal *Fish and Fisheries* appears to be the most influential, but all three journals are for-profit and none are considered cost-effective.

Within the subset of journals that we considered peers of the AFS general fisheries journals, there was a reasonable balance between journals published by for-profit and non-profit publishers (Table 3). Furthermore, some of the cost-effective non-profit journals were among the most influential applied fisheries journals, such as *Canadian Journal of Fisheries and Aquatic Sciences* and *TAFS*. However, as with the disease journals, IF and EF sometimes provided different rankings of relative journal influence, and influence was often inversely related to cost-effectiveness. For example, *Fisheries* and *Ecology of Freshwater Fish* ranked high in terms of IF but low in terms of EF, and the for-profit journal *Fisheries Oceanography* ranked high for influence but low for cost-effectiveness. Only one for-profit journal, *Journal of Freshwater Ecology*, was highly cost-effective and rated a High Value, but it ranked near the bottom of the list on both influence metrics. The situation for *NAJFM* is interesting—it did not rank particularly high with regard to either influence metric, perhaps reflective of its management emphasis, but was ranked highly with regard to cost-effectiveness.

The principal components analysis clearly illustrated that the influence and cost-effectiveness metrics describe different things about the journals. Two components explained 91% of the variation in the data, as would be expected with only four variables included. One principal component axis explained variation in cost-effectiveness and the other explained variation in influence (Figure 4). All of the AFS general fisheries journals cluster together near the bottom center of the biplot with *Copeia*, *Bulletin of*

Figure 1. Comparison of the average Impact Factor between selected sets of applied and basic research journals during the period 1975–2007. Not all of the journals were indexed for the entire time period; the first year of inclusion is given in parentheses after the journal name. The set of 14 applied research journals includes *Canadian Journal of Fisheries and Aquatic Sciences* (1975), *Fishery Bulletin* (1975), *Journal of Applied Ecology* (1975), *Journal of Fish Biology* (1975), *North American Journal of Aquaculture* (1975), *Transactions of the American Fisheries Society* (1975), *Aquaculture* (1977), *Journal of Fish Diseases* (1979), *Fisheries* (1980), *Conservation Biology* (1990), *Ecological Applications* (1992), *ICES Journal of Marine Science* (1992), *Journal of Aquatic Animal Health* (1999), and *North American Journal of Fisheries Management* (2003). The set of 7 basic research journals includes *Copeia* (1975), *Ecology* (1975), *Oecologia* (1975), *Oikos* (1975), *Environmental Biology of Fishes* (1981), *Marine Ecology Progress Series* (1981), and *Ecology of Freshwater Fish* (1999).

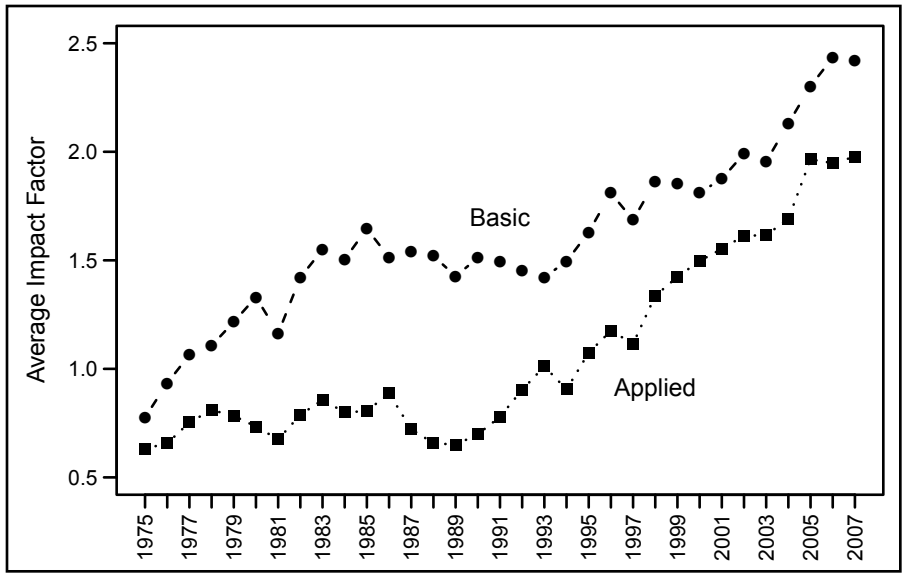


Figure 2. Comparison of the average Impact Factor among three sets of journals during the period 1975–2007: (1) the American Fisheries Society journals; (2) a set of other fisheries and aquatic sciences (F&AS) journals, both freshwater and marine, including representatives of both basic and applied research as well as the subdisciplines of aquaculture and disease; and (3) a set of basic and applied ecology journals. The included journals are the same as those used in Figure 1, except that the categorizations are different. Refer to the caption for Figure 1 for first years of inclusion. The set of 10 F&AS journals includes *Canadian Journal of Fisheries and Aquatic Sciences, Copeia, Fishery Bulletin, Journal of Fish Biology, Aquaculture, Journal of Fish Diseases, Environmental Biology of Fishes, Marine Ecology Progress Series, ICES Journal of Marine Science,* and *Ecology of Freshwater Fish.* The set of 6 ecology journals includes *Ecology, Journal of Applied Ecology, Oecologia, Oikos, Conservation Biology,* and *Ecological Applications*.

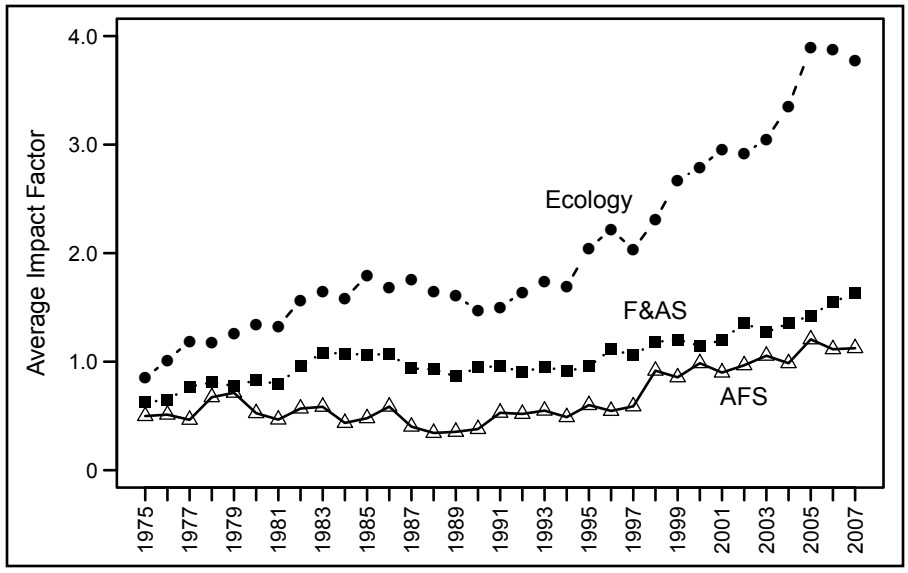
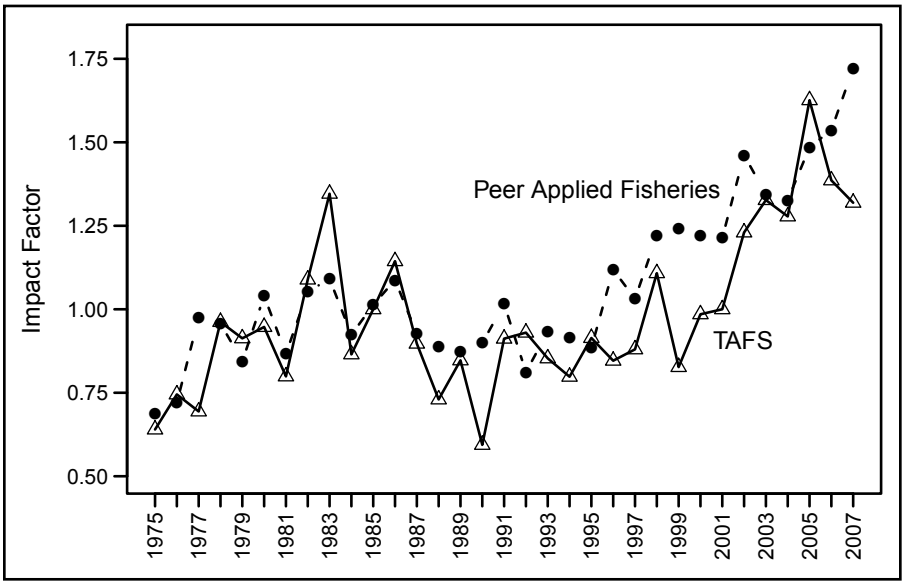


Figure 3. Comparison of the trend in Impact Factor from 1975 to 2007 between *Transactions of the American Fisheries Society* and the average across four peer applied fisheries journals (*Canadian Journal of Fisheries and Aquatic Sciences, Fishery Bulletin, Journal of Fish Biology,* and *ICES Journal of Marine Science*). All of the journals were indexed for the entire time period except *ICES Journal of Marine Science,* which was included beginning in 1992.



Marine Science, and *Fishery Bulletin*. Their position indicates that in comparison to this set of journals they are some of the most cost-effective journals (high influence relative to their subscription cost), but they are not in the top tier of citation-based influence.

DISCUSSION

Among fisheries and aquatic sciences journals, we found that metrics of influence and cost-effectiveness provide different portrayals of journals relative to their peers. Particularly for the journals published by AFS and other professional societies, evaluations based on cost-effectiveness can be much more positive than those based on influence metrics alone. The ideal journal is both highly influential and cost-effective, but a joint analysis of both metrics is not necessarily conclusive about the success of a journal. Metrics of cost-effectiveness such as PPEF are ratios, so journals with low citation rates can be ranked highly with regard to cost-effectiveness simply because the cost of a subscription is small enough to outweigh the relatively poor influence. Balance is needed between influence and cost-effectiveness when evaluating a journal.

Whereas our evaluation indicates that *TAFS* and *Fisheries* are competitive with highly regarded applied fisheries journals, our evaluation does not provide a conclusive assessment of whether *NAJFM*, *JAAH*, and *NAJA* are successful based only on influence and cost-effectiveness. The degree to which these two factors are weighted in the final analysis of whether a journal is successful depends on the goals that AFS and the editorial board have set for the journal. Nonetheless, the situation for the AFS aquaculture and disease journals (*JAAH* and *NAJA*) within their subdisciplines probably deserves attention.

The applied nature of much of fisheries science means that a substantial measure of the influence of a journal may be hidden from citation-based metrics like Impact Factor and Eigenfactor. For example, an article in *NAJFM* may be read widely by agency biologists and have substantial influence on local or regional fisheries management practices. The article may not garner many citations in the primary literature, but its on-the-ground influence is critically important and serves the purposes of AFS and the journal. Indeed, the history and aims of *NAJFM* make it clear that its primary purpose is to serve the fisheries management community by providing case studies and practical management experience. A similar argument could be made about *NAJA*. Furthermore, citations between basic and applied research journals might not be balanced, in that articles in applied journals are more likely to cite findings in basic

Table 2. Comparisons of influence and cost-effectiveness metrics among aquaculture, disease, and fisheries review journals. The Eigenfactor (EF) and Price per Eigenfactor (PPEF) columns are re-scaled for readability. See Box 1 for abbreviations and details on the metrics. American Fisheries Society journals are highlighted in yellow.

Journal title	EF*100	IF	PPEF/1000	RPI	Value (profit status)
Aquaculture Journals					
Aquaculture	2.84	1.73	138	1.36	Medium (For)
Journal of the World Aquaculture Society	0.23	0.63	158	1.41	Medium (Non)
North American Journal of Aquaculture	0.10	0.53	45	0.23	High (Non)
Disease Journals					
Journal of Fish Diseases	0.55	1.70	321	4.44	Low (For)
Diseases of Aquatic Organisms	1.04	1.49	120	1.89	Medium (For)
Journal of Aquatic Animal Health	0.19	0.95	26	0.28	High (Non)
Review Journals					
Fish and Fisheries	0.44[1]	4.34	169	4.85	Low (For)
Reviews in Fisheries Science	0.10	1.95	1053	11.73	Low (For)
Reviews in Fish Biology and Fisheries	0.26	1.64	362	9.00	Low (For)

1 Only includes data for 2005 and 2006

Table 3. Comparison of influence and cost-effectiveness metrics among the 27 journals considered peers of the AFS general fisheries journals (*TAFS*, *NAJFM*, and *Fisheries*) and the 10 general ecology journals. See Box 1 for abbreviations and details on the metrics. American Fisheries Society journals are highlighted in yellow, and the 14 journals deemed to be the most direct peers of AFS journals based on the citation analysis of McCain (1994) as well as our judgment are highlighted at the top.

Journal title	EF*100	IF	PPEF/1000	RPI	Value (profit status)
Fisheries and Aquatic Sciences Journals					
Fisheries Oceanography	0.64	2.10	173	3.31	Low (For)
Canadian Journal of Fisheries and Aquatic Sciences (CJFAS)	3.24	1.96	34	0.63	High (Non)
Fisheries	0.34	1.84	26	0.40	High (Non)
ICES Journal of Marine Science	1.46	1.54	78	1.05	High (Non)
Fishery Bulletin	0.65	1.49	11	0.18	High (Non)
Transactions of the American Fisheries Society (TAFS)	0.99	1.44	5	0.06	High (Non)
Journal of Fish Biology	2.20	1.33	146	2.05	Medium (For)
Ecology of Freshwater Fish	0.20	1.25	277	3.06	Low (For)
Fisheries Research	1.01	1.19	220	2.48	Medium (For)
Fisheries Management and Ecology	0.16	1.12	547	4.97	Low (For)
Environmental Biology of Fishes	0.84	0.99	292	3.93	Low (For)
Copeia	0.72	0.98	22	0.30	High (Non)
North American Journal of Fisheries Management (NAJFM)	0.51	0.98	10	0.08	High (Non)
Journal of Applied Ichthyology	0.26	0.68	296	2.49	Medium (For)
Limnology and Oceanography (L&O)	4.93	3.27	8	0.19	High (Non)
Freshwater Biology	2.30	2.65	174	3.37	Low (For)
Marine Ecology Progress Series (MEPS)	7.17	2.38	113	2.06	Medium (For)
Marine Biology	2.81	1.91	254	4.07	Low (For)
Journal of Exp. Marine Biology and Ecology (JEMBE)	2.15	1.78	236	3.36	Low (For)
Estuarine Coastal and Shelf Science	1.71	1.72	137	1.75	Medium (For)
River Research and Applications	0.23	1.54	442	3.57	Low (For)
Marine and Freshwater Research	0.87	1.52	144	2.32	Medium (Non)
Estuaries and Coasts	1.04	1.49	66	0.89	High (Non)
Aquatic Conservation: Marine and Freshwater Ecosystems	0.29	1.47	369	3.06	Low (For)
Hydrobiologia	2.96	1.08	324	3.80	Low (For)
Bulletin of Marine Science	0.77	0.90	80	1.06	High (Non)
Journal of Freshwater Ecology	0.17	0.48	78	0.43	High (For)
Ecology Journals					
Trends in Ecology and Evolution	7.05	14.60	21	1.23	High (For)
Ecology Letters	4.26	6.99	34	1.30	Medium (For)
Ecology	10.37	4.70	7	0.24	High (Non)
Frontiers in Ecology and the Environment	0.51	4.62	29	0.50	High (Non)
Journal of Applied Ecology	2.07	4.45	49	1.04	High (Non)
Conservation Biology	4.41	3.94	16	0.30	High (Non)
Ecological Applications	4.31	3.62	8	0.21	High (Non)
Oikos	5.24	3.28	22	0.55	High (Non)
Oecologia	6.49	3.11	84	2.16	Medium (For)
Biological Conservation	3.29	2.91	76	0.91	High (For)

research journals as foundations for their work than vice versa. For these reasons, we should not expect applied fisheries journals, including AFS journals, to compete with journals such as *Limnology and Oceanography* on the basis of citations. We suggest that AFS supplement future journal evaluations with other approaches to measure the influence of applied journals, such as surveys of agency biologists and managers or detailed summaries of journal article downloads (usage statistics).

Although journals provide important revenue streams for AFS, the fundamental purposes of AFS journals differ from those of commercial publishers. The constitutional objectives of AFS as well as the focus areas of its strategic plan rely on broad and timely dissemination of products related to fisheries science and conservation. As a critical component of these efforts, journals must be affordable and accessible to the global fisheries community, and these objectives will sometimes take precedence over efforts to increase the citation-based influence of AFS journals relative to their peers. For example, if AFS journals become overly selective about manuscripts or otherwise limit the number of journal articles in pursuit of higher citation rates, the dissemination of important information may be impeded. In addition, AFS journals play an important role as outlets for scientific products both by and for a diverse AFS membership. We suggest that there is an intrinsic trade-off between the objectives of AFS journals and efforts to increase citation-based influence metrics. As such, the success of

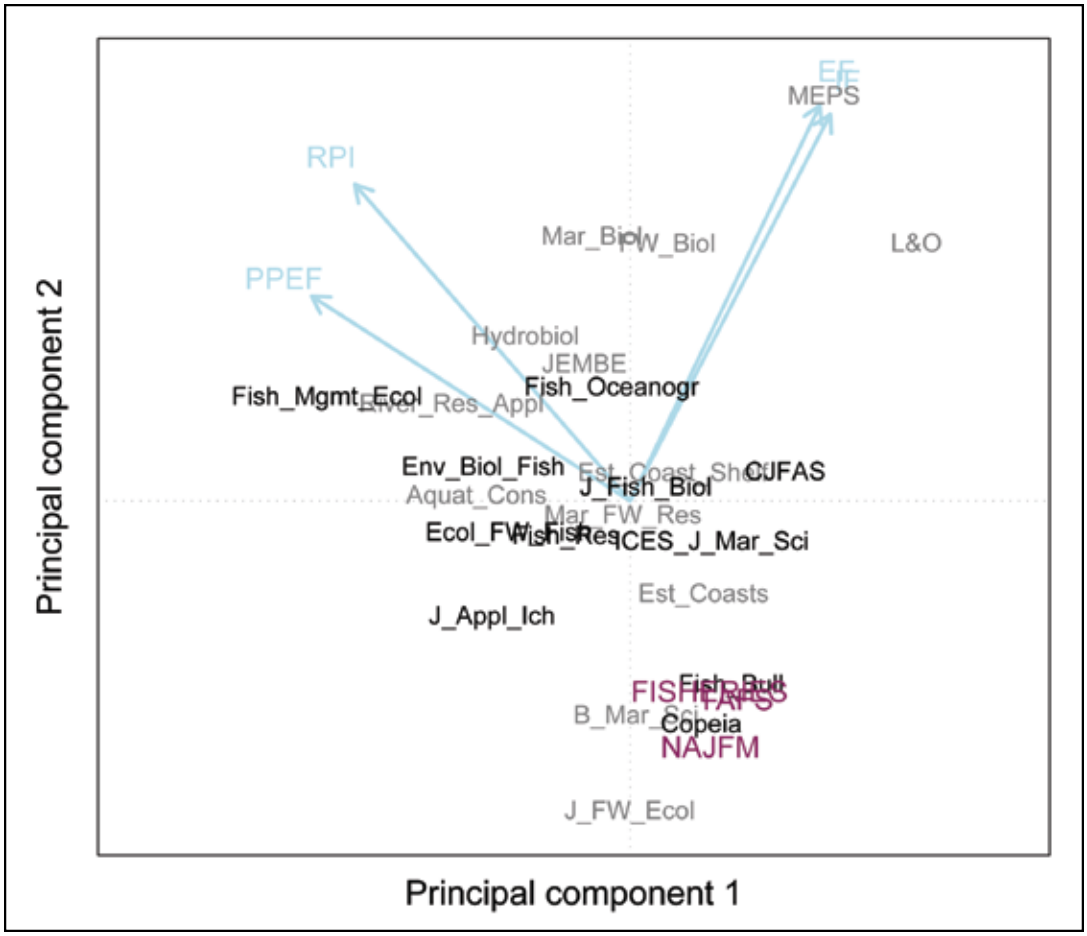


Figure 4. Biplot resulting from a principal components analysis (PCA) for the subset of journals included in Table 3. The most recent data for influence and cost-effectiveness metrics (IF [2007]; EF, PPEF, RPI [2006]) were scaled prior to analysis and the PCA was performed using singular value decomposition with the `rda` function in the `vegan` package for R (Okansen et al. 2009; R Development Core Team 2009). The first component (x-axis) explains mostly variation in cost-effectiveness metrics and the second component (y-axis) explains mostly variation in influence metrics. For readability, the abbreviations of the AFS journal names are written larger and in maroon, the abbreviations for the most direct peer journals (those at the top of Table 3) are written in black, and the abbreviations for less direct peers are written in gray. The most influential journals are toward the top right (e.g., *MEPS* and *L&O*) and the most cost-effective are toward the bottom right, where the AFS journals lie.

AFS journals might be better judged on the basis of cost-effectiveness and other criteria.

Concerns about journal value and cost-effectiveness are relatively new, but they have important implications for the progress of science and are relevant to the mission of AFS. Scientists are both the primary producers and consumers of journal articles, and contribute free peer review services, so authors and volunteer editors must exert some influence on the economics of the publication process. Some commercial publishers control hundreds or thousands of journals and devote so much effort to maximizing profits that they impede the exchange of peer-reviewed information (Rosenzweig 2000; Bergstrom and Bergstrom 2004). Given the recent profusion of journals and ongoing increases in subscription costs, even large academic libraries are fiscally challenged to provide continued and comprehensive access to researchers in the varied disciplines at their institutions (McGuigan 2004; Moghaddam 2007). As a result, journal circulation is strongly positively related to journal cost-effectiveness, and circulation can be expected to feed back on citation rates (Bergstrom and Bergstrom 2006; Evans and Reimer 2009).

The success of open access publications, such as those of the Public Library of Science (PLoS; www.plos.org), have demonstrated that the results of highly influential research can be made available to a wide readership at low cost (e.g., PLoS Biology: 2006 EF*100 = 8.9, 2007 IF = 13.5). We found that scientists publishing in fisheries and aquatic sciences journals have options from non-profit publishers like AFS that strike a reasonable balance between influence and cost-effectiveness, similar to findings for ecology (e.g., the journals of the Ecological Society of America; Bergstrom and Bergstrom 2006). Review journals specifically for fisheries are an exception, and we suggest that AFS journals, including the new open access *Marine and Coastal Fisheries* journal, may be able to help fill this gap in the marketplace.

As an extension of our assessment, we offer some suggestions that might help increase the influence of AFS journals without unduly compromising their accessibility and affordability:

1. The AFS journals web site could more prominently display the aims and scopes of the journals, and potentially other information. This type of information is currently buried in the Guides to Authors, in contrast to the practices of other professional societies (e.g., CERF, www.erf.org/journal).
2. Although all AFS journals occasionally publish review articles, editors could more vigorously solicit timely, synthetic reviews on emerging or contentious topics. Such contributions are likely to be cited more frequently than regular articles, but are also especially useful in guiding scientific inquiry. Special sections including multiple articles could also be more often organized or solicited for a journal.
3. AFS could take further steps to reduce time-to-publication, including:
   a. Encouraging editors and associate editors to more aggressively screen manuscripts prior to peer review, in order to better match manuscripts to journals and more effectively allocate effort from volunteer reviewers and editors; and
   b. Reducing the amount of time given to authors to make revisions on accepted manuscripts (currently six months).
4. AFS could encourage editors to be more involved in developing and revising the aims and scopes of the journals, in collaboration

with the Publications Overview Committee. If revisions were made annually, they would help keep the journals current, provide a "vision" for the journals, and provide a basis for editors to actively solicit high quality manuscripts from colleagues or presenters at scientific meetings that contribute to the vision (e.g., articles on emerging or contentious topics).

5. AFS could consider expanding the content of the journals to include more international coverage, at the same time potentially changing the name of the journals *NAJFM* and *NAJA*.
6. AFS could consider expanding the content of the journals to include topics related to other trophic levels and aquatic processes, but still directly related to fisheries. We can envision a place for some articles that are now more often directed to journals like *Canadian Journal of Fisheries and Aquatic Sciences*, *Limnology and Oceanography*, and *Marine Ecology Progress Series*.

In conclusion, we argue that AFS journals serve the purposes of the Society and its membership well by publishing a balance of high quality articles that are influential in the literature as well as contribute to the applied aspects of fisheries research and management, and by being some of the most accessible and affordable journals in the marketplace. We feel that most of the AFS journals are competitive based on these criteria, and that the citation-based influence of *TAFS*, *NAJFM*, and *Fisheries* are reasonable. Nonetheless, we encourage continuous efforts to increase the influence (of any kind) of AFS journals, particularly *NAJA* and *JAAH*, and to adapt them to the changing landscape of scientific publishing. Given the recent pace of change in publishing practices, maintaining the competitiveness of the AFS journals will require more frequent evaluations of the type we have conducted here, as well as continued attention to the methods used to judge the success of the journals (particularly for *NAJFM*). Such evaluations will allow AFS to stay abreast of how the journals are doing and identify strategies to improve them.

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A Vision for Climate Services in NOAA

Co-chairs Susan Solomon and Randall Dole, Richard Feely, Isaac Held, Wayne Higgins, Jeff Payne,Eileen Shea, Usha Varanasi, and Marian Westley.

Climate change is widely regarded as among the most challenging environmental issues ever faced by humanity. The National Oceanic and Atmospheric Administration (NOAA) is working to enhance its climate services by creating a comprehensive and coordinated approach to providing information to support adaptation and mitigation of climate change and its impacts, including those important for human life and coastal/marine ecosystems. NOAA has recently published a report entitled, "A Vision for Climate Services in NOAA," (available at www.climate.noaa.gov/pdf/GandPdocumentOct21.pdf) that provides a set of goals and principles for these services from the view of a group of NOAA scientists and related experts. Below is an abridged version of this document, with particular emphasis on ecosystem and fisheries considerations.

The authors work at National Oceanic Atmospheric Administration. Co-chairs Solomon and Dole, and Feely, Held, and Westley work in the Office of Oceanic and Atmospheric Research. Higgins works at the National Weather Service. Payne works at the National Ocean Service. Shea works at the National Environmental Satellite, Data, and Information Service. Varanasi works at the National Marine Fisheries Service. Varanasi can be contacted at Usha.Varanasi@noaa.gov.

1. WHY ESTABLISH NOAA CLIMATE SERVICES?

There is unequivocal evidence that the Earth is warming. This warming has been manifested by increases in global-average surface air and ocean temperatures, widespread melting of snow and ice, rising sea level, and changes in numerous other climate-related variables and impacts (IPCC 2007). Most of the observed increases in global temperatures since the mid-twentieth century are very likely due to human-induced emissions of greenhouse gases (IPCC 2007), and warming is expected to continue for decades or more. Under a broad range of non-mitigation scenarios considered by the IPCC, warming over this century is projected to be substantially larger than over the past century. Changes in many other components of the climate system, precipitation patterns being but one example, are expected to be larger than those observed in the present century. The prospects of such climate changes have profound implications for global society and the environment, underscoring the need for scientific information to aid decision makers in developing and evaluating options for mitigating future anthropogenic climate change as well as alternatives for adapting to a changing climate.

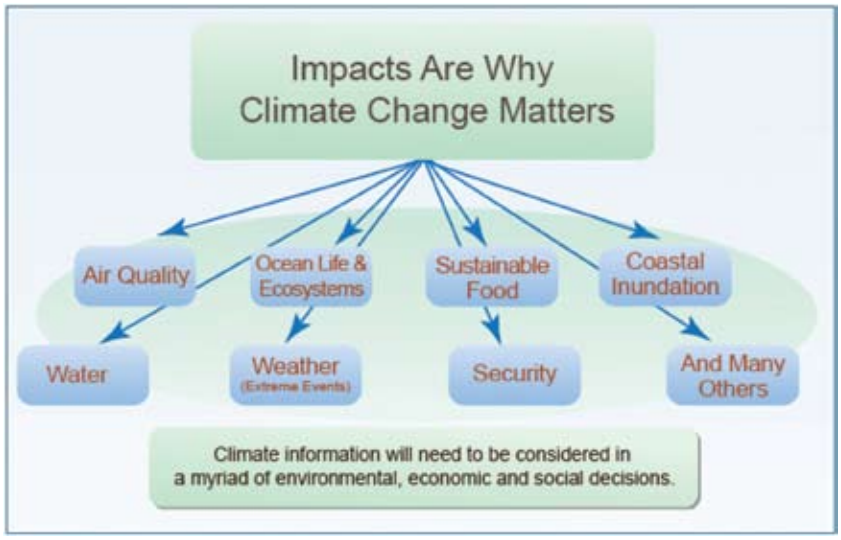
Future impacts of a changing climate are expected to be regionally diverse and relevant across numerous sectors, including water, energy, transportation, forestry, coasts, fisheries, agriculture, ecosystems, and human health (USGCRP 2009). These impacts are anticipated to grow in response to projected future climate change, so that wise adaptation planning is required (see Figure 1).

Addressing these challenges will require access to the best climate knowledge and information that science can provide. Climate services are required to provide credible and authoritative climate information that will assist the nation and by extension the world in developing and evaluating policy options for climate change mitigation and enable decision makers, resource managers, and the public to better anticipate, plan for, and adapt to impacts of climate change and variability.

2. WHY NOAA?

NOAA's mission is to understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental

Figure 1. Impacts are why climate change matters.



needs. NOAA's mandate for climate activities was established by the National Climate Program Act of 1978. As the lead federal agency responsible for delivering national weather, ocean, fishery, coastal, satellite, and environmental data products and services for informing decisions, NOAA has unique breadth of mandate and experience in environmental service delivery that provides a strong foundation for many types of climate services. NOAA works closely with an extensive user community from national to local levels, an essential prerequisite for creating effective services. NOAA currently provides multiple capabilities and coordinates with other agencies and partners, but more capability and coordination are needed for effective national climate services (see Sections 3 and 4).

NOAA currently maintains most of the nation's sustained climate observing networks, houses the nation's permanent archive of weather, climate, and oceanographic data through its data centers, and ensures the continuity and integrity of the historical climate record through data stewardship. NOAA also provides analyses of the observed records, including the nation's climate statistics and reanalysis of observations and initial conditions for climate prediction. It also makes major contributions to the process studies required to attribute the causes of climate change.

NOAA's coastal and marine resource managers are among the vanguard of users of climate information, and are natural partners in understanding and planning for the impacts of a changing climate. In addition to its responsibilities under the Magnuson Stevens Fishery Conservation and Management Act and the Endangered Species Act, NOAA implements the Marine Mammal Protection Act, the National Marine Sanctuaries Act, and the Coastal Zone Management Act. NOAA managers must account for the effects of climate variability and change on coastal and marine ecosystems, resources, and communities, and adapt their management practices accordingly. Conditions and processes of concern affected by a changing climate include: ocean temperatures, water levels in coastal regions and the Great Lakes, sea and lake ice cover, ocean current patterns, freshwater supply, saltwater intrusion, atmospheric extremes, occurrence of hypoxia and harmful algal blooms, and changes in disease patterns.

Box 1. Climate Services and Fisheries Management

Climate change is expected to have major impacts on fisheries resources. The U.S. Global Research Program (USGRP 2009) found that:

- Coastal and near-shore ecosystems are already under multiple stresses. Climate change and ocean acidification will exacerbate these stresses.
- The habitats of some coldwater fish, such as salmon and trout, are very likely to contract in response to warming.
- Some of the benefits ecosystems provide to society will be threatened by climate change, while others will be enhanced.

NOAA climate services will work to improve climate projections on smaller spatial and temporal scales that are relevant to fisheries management. Reducing climate change uncertainty will provide the scientific underpinning that supports more accurate stock assessments and harvest levels, as well as the sustainability and economic vitality of national and global fisheries.

3. WHAT: THE GOALS AND SCOPE OF NOAA'S CLIMATE SERVICES

The overarching goal of NOAA's climate services is to provide the essential climate change information needed for effective decision making. Scientific information to assist environmental decision making has three fundamental components: credibility ("Is it real?"), manageability ("What can we do about it?"), and accountability ("Did the solutions taken work?"). NOAA's climate services must address all three components.

NOAA's climate services consist of products, services, and the core infrastructure upon which the products and services are built. Working with its partners, NOAA's climate services must ensure that the following core components of an end-to-end climate service are planned, built, and sustained:

- A climate observing system;
- Effective data management and delivery systems;
- Research that underpins the service and establishes the scientific feasibility of evolving products;
- Climate modeling for predictions and projections;
- Regional, national, and international assessments;
- Public understanding; and
- User outreach and technical assistance.

A near-term goal of NOAA's climate services must be to initiate a continuing assessment of key regional "pressure points" important for impacts on the nation and potentially strongly affected by anthropogenic climate change (such as hurricane trends affecting the East and Gulf coasts). NOAA's climate services must assess, and work to improve, the credibility and communication of the regional climate projections to address these impacts.

As the climate change challenge evolves and broadens, a key goal for NOAA's climate services is to be both highly responsive to user needs and able to lead based upon expert evaluation of new data and knowledge. This requires that NOAA's climate services develop products and services that can evolve, and be initiated rapidly when needed, in response to scientific information as it emerges. A balance respecting the dual demands of "user-pull" and "science-push" must guide the nature and scope of the services.

NOAA's climate services must seek to identify an early suite of products and services (development time of less than five years) that can assist a number of pressing social, economic, and environmental climate change decisions, particularly those at national and regional levels. Products and capabilities that NOAA's climate services might provide include:

- An early-warning system to document ocean acidification and evaluate related ecosystem impacts (See Box 2);

Box 2. An Ocean Acidification Observing Network for Climate Services

The same anthropogenic increase in carbon dioxide concentration in the atmosphere that is causing climate change is also forcing more carbon dioxide into our oceans, causing changes in seawater chemistry known as "ocean acidification." Ocean acidification presents a separate suite of environmental changes that will affect ocean ecosystems, fisheries, and other marine resources in profound ways, such as reducing the ability of many organisms to build their shells or skeletons, and changing organisms and ecosystems in ways that affect the carbon and nitrogen cycles. More accurate and reliable predictions of the rate, severity, and ecological impact of ocean acidification are needed to improve forecasts of ocean pH conditions and the consequences for marine organisms. These forecasts are in turn required to assess the corresponding socioeconomic impacts and develop adaptive management strategies for our fish and shellfish industries. An essential component of NOAA's plan is to establish ocean acidification monitoring stations at strategic open-ocean and coastal sites designed to characterize the carbon chemistry and track changes in these ecosystem responses in particularly vulnerable regions including coral reefs, estuarine, and coastal regions.

- Improved sea level predictions and impacts information to enhance coastal zone management;
- The National Integrated Drought Information System; and
- An improved Arctic sea ice monitoring and analysis system allowing evaluation of coastal erosion threats and linkages to Arctic ecosystem changes.

4. WITH WHOM AND HOW

The scope of the full range of challenges posed by climate change far exceeds the authority, capability, and resources of any single organization. NOAA alone cannot meet all of the nation's needs for climate information and services; partnerships from federal to local levels, including other agencies, the academic community, and private sector will be essential to fully meet the nation's needs. NOAA can bring forward existing major capabilities and continue to expand its work with national and international partners.

The following are considered to be strategic principles for NOAA's climate services:

What we will do...

- Be an "honest broker."
- Focus on anthropogenic climate change, but link anthropogenic climate change and variability to meet broad user needs.
- Provide products and services to minimize climate-related risks.
- Provide predictions and projections relevant to decision support.
- Strengthen observations, standards, and data stewardship.
- Ensure timely assessments.
- Inform policy options.
- Inform regulatory decisions and management options of others.
- Foster climate literacy and workforce development.

In a manner that...

- Commits to a service-centric approach.
- Balances present and future information needs (shared learning between users and providers).
- Encourages public-private partnership.
- Ensures robust products grounded in sound science, fostering sustained collaborations with partners including those in other agencies and academia.

Requirements...

- Maintain an open and engaged scientific capability.
- Support problem-focused research.
- Characterize uncertainties.

In the coming months and years, utilizing this guiding document, NOAA will work to meet its overarching climate service goal of providing the essential climate change information needed for effective decision-making. NOAA's climate services will seek to identify an early suite of products and services that can assist a number of key social, economic, and environmental climate change decisions, such as management of natural resources like fisheries and associated habitats. It is also clear that addressing climate change will require evolving needs for information to support decision-making over not just a few years but over many decades.

ACKNOWLEDGEMENTS:

The authors thank Thomas Karl and Chester Koblinsky for their support and encouragement in the completion of this report.

REFERENCES

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M.Tignor, and H. L. Miller, eds. Cambridge University Press, Cambridge, UK, and New York.

USGCRP (United States Global Change Research Program). 2009. Global climate change impacts in the United States. T. R. Karl, J. M. Melillo, and T. C. Peterson, eds. Cambridge University Press, New York.

PHOTOS BY TODD MASZAROS, DON KING, AND BETH BEARD.

AWARD OF EXCELLENCE
Professor Carl Schreck, Department of Fisheries and Wildlife at Oregon State University and Leader of the Oregon Cooperative Fish and Wildlife Research Unit, receives the Award of Excellence from Bill Franzin. He is honored for his for his activity in fisheries, aquaculture, endocrinology, immunology, and environmental physiology, and fish passage. He has also served as major professor for 50 graduate students and on numerous scientific panels.

WILLIAM E. RICKER RESOURCE CONSERVATION AWARD
David A. Fournier, partner and president, Otter Consulting, Ltd., receives the William E. Ricker Resource Conservation from Bill Franzin. Fournier's ground-breaking work on quantitative assessments in fisheries and natural resources has provided fisheries practitioners with statistical software to improve stock assessments worldwide.

CARL R. SULLIVAN FISHERY CONSERVATION AWARD
Ransom Myers, Dalhousie University, receives "The Sully" posthumously. **Jeff Hutchings** and **Myers family** accept the award for Myers from Bill Franzin. Myers is honored as a mathematically gifted scientist who was committed to the unconstrained communication of science to decision makers and society. Myers made significant contributions to the fields of fisheries science and marine conservation, as well as communicating the plight of the world's oceans to colleagues, the public, and policy makers in Canada, the United States, and elsewhere.

MERITORIOUS SERVICE AWARD
F. Joseph Margraf, University of Alaska Fairbanks, receives the Meritorious Service Award from Bill Franzin. Margraf is recognized for his service to AFS including six years as Constitutional Consultant, service as co-instructor of AFS leadership training, fostering student participation in AFS activities, and leadership of a Division, Chapter, and several Sections.

THE PRESIDENT'S FISHERY CONSERVATION AWARD TO A MEMBER
David W. Willis, chair of the Department of Fisheries and Wildlife Science at South Dakota State University, receives the President's Fishery Conservation Award from Bill Franzin. Willis is recognized for his leadership in freshwater fisheries management in the Great Plains region, particularly studies on predator-prey interactions, reservoir and small impoundment management, and sport fisheries enhancement.

THE PRESIDENT'S FISHERY CONSERVATION AWARD TO A NON-AFS INSTITUTION
The Hudson River Foundation (HRF), represented by **Executive Director Clay Hiles,** receives the President's Fishery Conservation Award from Bill Franzin. HRF is recognized for it's unique contribution to improving the understanding of the status, ecology, and threats to the fishes of the Hudson River ecosystem.

DIVERSITY the foundation of fisheries and of AFS: Are we gaining ground?

THE EMMELINE MOORE PRIZE

Bradford E. Brown, NOAA, retired, received the AFS's new Emmeline Moore Prize from Bill Franzin. The award is named after Emmeline Moore, who was AFS president from 1927–1928 and was the first female president. The award recognizes career achievement in the promotion of demographic diversity in the society.

Brown was elected as president of the Miami Dade Chapter of the National Association for the Advancement of Colored People (NAACP) and was an invited guest on local talk shows on TV where he articulated the message of equal opportunity and raised the profile of the local chapter of the NAACP. Brown is also an active member of the National Organization of Women. As director of the Southeast Fisheries Science Center (SEFSC), Brown increased the distribution of vacancy announcements to include advertisement in minority and women's publications, particularly at academic institutions, and developed a diverse workforce at all the laboratories in the SEFSC.

DISTINGUISHED SERVICE AWARDS

Steven Cooke, assistant professor at Carleton University, Ottawa, Canada, receives a Distinguished Service Award from Bill Franzin. Cooke is applauded for his outstanding work as chair of the AFS Publications Oversight Committee (POC) during a period of transition for the committee. His energetic and dynamic leadership positioned the POC to move forward with development of an open-access, electronic format journal for AFS. This new AFS journal, *Marine and Coastal Fisheries,* was successfully launched in February 2009.

Melissa Wuellner, a Ph.D. student at South Dakota State University, receives a Distinguished Service Award from Bill Franzine. Wuellner served as an outstanding president of the Student Subsection of the AFS Education Section. She was the driving force in a collaborative effort with the AFS Membership Committee in drafting a guidance document for the AFS Governing Board that addresses AFS student and young professional recruitment.

EXCELLENCE IN FISHERIES EDUCATION AWARD

Michael Hansen, University of Wisconsin—Stevens Point, receives the Excellence in Fisheries Education Award from Bill Franzin. Hansen has directed 2 Ph.D. and 19 M.S. students to completion and advises over 50 students each year. He draws on more than 15 years in fisheries in the private sector, state government, and federal government. "One of Mike's strongest talents as a teacher is his ability to bring relevance to subject matter and provide students with a window into the world of fisheries management," one student declared. He is always willing to help students find their own solutions to problems.

GOLDEN MEMBERSHIP AWARDS
AFS Members for 50 Years
Class of 1960

William D. Anderson
Gilbert W. Bane
Louis Barr
Daniel W. Coble
Gary D. Doxtater
David M. Green
Ned E. Fogle
Edward C. Greenhood
Donald C. Hales
Robert F. Hartmann
Janice S. Hughes
Thomas M. Jolliff
Robert A. Jones
Alexis E. Knight
Harold W. Lorz
Charles H. Meacham
L. G. McBay
Eugene L. Nakamura
William A. Nisbet
Walter T. Pereyra
Ronald Preston
John S. Ramsey
James B. Reynolds
Wilmer A. Rogers
Matthew Scott
Quentin J. Stober

J. FRANCES ALLEN SCHOLARSHIP

Karen Murchie, Department of Biology Carleton University, Ottawa, Canada, receives the J. Frances Allen Scholarship from Bill Franzine. Murchie is a Natural Sciences and Engineering Research Council Ph.D. student and a member of the Flats Ecology and Conservation Program at the Cape Eleuthera Institute in the Bahamas where she conducts her field studies under the co-supervision of Steven Cooke and Andy Danylchuk. Murchie's dissertation research is focused on linking organismal biology with environmental variability and ecosystem processes in tropical tidal flats systems, using bonefish as a model to determine how animals make a living in such dynamic environments and how energy flows through tidal flats habitats.

Heidi Lewis, Southern Illinois University at Carbondale, receives the J. Francis Allen runner-up award from Bill Franzin. Lewis is a Ph.D. student in Chris Kohler's lab, where she completed her M.S. evaluating plant-based protein and lipid sources as alternatives to marine feedstuffs for hybrid striped bass production. Her disertation focuses on improving reproductive performance and larval vigor of *Morone* spp. by identifying ideal lipid sources for use in female white bass broodstock diets while minimizing dependence on marine sources of highly unsaturated fatty acids. She is past president of Southern Illinois University's AFS Student Subunit.

OUTSTANDING CHAPTER AWARD—LARGE CHAPTER (100 members or more) **The Oregon Chapter** is the Outstanding Chapter and President Elect **Richard Grost** accepts the award from Bill Franzin. The Chapter organized and sponsored the highly successful 2008 Western Division annual meeting in Portland, contributed $2,000 to the Oregon State University Student (OSU) Subunit also known as the OSU Fish and Wildlife Club, and published and distributed *Piscatorial Press,* a quarterly newsletter. They also organized and presented six continuing education workshops for more than 300 professionals at the 2008 Oregon Chapter/Western Division AFS annual meeting and established the Dr. Carl Bond Memorial Student Scholarship in memory of the Oregon ichthyologist.

OUTSTANDING STUDENT SUBUNIT AWARD—A TIE

The Palouse Student Subunit, University of Idaho and North Idaho College, receives the Outstanding Student Subunit Award. President **Tarah Johnson** accepts the certificate from Bill Franzin. Undergraduate and graduate students volunteered in activities such as bull trout redd counts with the U.S. Forest Service and an environmental third-grader native fish workshop. They provide networking, educational, and professional development opportunities for members outside the University of Idaho. They actively participate by working as volunteers at the Idaho Chapter AFS annual meeting in Boise. The Subunit also organized the Second Annual Sturgeon Fishing Trip with the Idaho Department of Fish and Game on the Snake River.

The Lake Superior State University Student Subunit (LSSU) receives the Outstanding Student Subunit Award. President **Brandon Gerig,** Past President **Brianne Lunn,** and Vice President **Doug Galvas** display their award with Bill Franzin. For two consecutive years the LSSU Student Subunit, which is comprised of only undergraduate students, has been awarded the most active Student Subunit in the North Central Division. Members served on committees revising recycling policies, evaluating energy use, and educating students, staff, and faculty about steps to sustainability as part of the LSSU Sustainability Initiative. Members educated young people about fisheries and natural resources at Occupational Education Day and Kid's Fishing Day. The unit and its members received several awards and recognition for their outstanding contributions in professional development, scientific contributions and outreach, including 3 Fenske Award finalists and best student paper and poster presentations, at the Michigan Chapter annual meeting.

THE JOHN E. SKINNER MEMORIAL FUND

The following deserving graduate students or exceptional undergraduate students received monetary travel awards to attend the AFS Annual Meeting. Certificates were presented by Bill Franzin.

WINNERS (top photo)

Marybeth Brey	North Carolina State University
Joe Gerken	Kansas State University
Marie-Ange Gravel	Carleton University
Andrew Hafs	West Virginia University
Caleb Hasler	Carleton University
Tarah Johnson	University of Idaho
Cecilia Krahforst	East Carolina University
Karen Murchie	Carleton University
Lora Tennant	Montana State University
Justin VanDeHey	South Dakota State University

HONORABLE MENTIONS

Alison Colotelo	Carleton University
Daniel Farrae	University of Georgia
Connie O'Connor	Carleton University
James Thorson	Virginia Tech
Daniel Weaver	NC State University

STUDENT WRITING CONTEST
Steven Gray, Rutgers University, won the Outstanding Student Paper award for his paper titled, "Are Robots and Satelites the Future of Fisheries Managaement?" which will be printed in an upcoming issue of *Fisheries*.

STEVEN BERKELEY MARINE CONSERVATION FELLOWSHIP
This fellowship was created by AFS in 2007 to honor the memory of Steven Berkeley, a dedicated fisheries scientist with a passionate interest in integrating the fields of marine ecology, conservation biology, and fisheries science to improve fisheries management. The fellowship comprises a competitively based $10,000 award to a graduate student actively engaged in thesis research relevant to marine conservation.

Aleksandra Maljkovic, Simon Fraser University, is the winner of the award**.**

Honorable Mention was awarded to **Jack Kittinger,** University of Hawai'i at Ma-noa, and **Annie Schmidt,** University of California, Davis.

PUBLICATION AWARDS

THE ROBERT L. KENDALL BEST PAPER IN TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY
The winner is "Climate Regime Effects on Pacific Herring Growth Using Coupled Nutrient-Phytoplankton Zooplankton and Bioenergetics Models" by **Kenneth A Rose, Bernard A. Megrey, Douglas Hay, Francisco Werner** and **Jake Schweigert.** Rose accepts the certificate from Bill Franzin.

THE BEST PAPER IN THE JOURNAL OF AQUATIC ANIMAL HEALTH
The winner is "Decreased Mortality of Lake Michigan Chinook Salmon after Bacterial Kidney Disease Challenge: Evidence for Pathogen-Driven Selection?" by **Maureen K. Purcell, Anthony L. Murray, Anna Elz, Linda K. Park, Susan V. Marcquenski, James R. Winton, Stewart W. Alcorn, Ronald J. Pascho,** and **Diane G. Elliott.** Purcell accepts the award from Bill Franzin.

THE MERCER PATRIARCHE BEST PAPER IN NORTH AMERICAN JOURNAL OF FISHERIES MANAGEMENT:
The winer is "An Ecosystem Approach for Assessment Advice and Biological Reference Points for the Gulf of Maine–Georges Bank Atlantic Herring Complex" by **W. J. Overholtz, L. D. Jacobson,** and **J. S. Link.** Jacobson accepts the certificate from Bill Franzin.

THE BEST PAPER IN THE NORTH AMERICAN JOURNAL OF AQUACULTURE
The winner is "Farm-level Economic Impacts of *Bolbophorus* Infections of Channel Catfish" by **David J. Wise, Terrill R. Hanson,** and **Craig S. Tucker.** Wise accepts the certificate from Bill Franzin.

SECTION AWARDS

EQUAL OPPORTUNITIES SECTION

Mentor Award:
Benjamin Cuker, Hampton University

EDUCATION SECTION

AFS Best Student Poster Award at the 2008 Annual Meeting in Ottawa, Canada
"Age and Growth of the Threatened Spotted Gar (*Lepisosteus oculatus*) in Rondeau Bay, Southwestern Ontario"
William R. Glass, University of Windsor

AFS Best Student Paper Award at the 2008 Annual Meeting in Ottawa, Canada
"Density-dependent Growth and Energy Acquisition Dynamics of Central Appalachian Brook Trout"
Ryan M. Utz, University of Maryland Center for Environmental Science

Paper Honorable Mentions:
"Why Saugeye Are Where They Are"
Cassandra May, Ohio State University
And "Dietary Fatty Acid Composition Differentially Impacts White Bass Oocyte Composition and Larval Quality"
Heidi A. Lewis, Southern Illinois University

ESTUARIES SECTION

Student Travel Award:
Bridgette Froeschke, Texas A&M University
Jeanne-Marie Havrylkoff,
University of Southern Mississippi
Erik Lang, University of Southern Mississippi
Edward McGinley, West Virginia University
Nancy Foster Habitat Conservation Award:
Si Simenstad

FISHERIES MANAGEMENT SECTION

Conservation Achievement Award:
Project SHARE
(Salmon Habitat and River Enhancement)

Award of Excellence:
David Bennett

Award of Merit:
A. Lawrence "Larry" Kolz

Hall of Excellence:
Wayne Tody, Dennis Unkenholz,
and **Scott Van Horn**

GENETICS SECTION

James E. Wright Award:
Yen Duong and **Jamie Roberts**

Stevan Phelps Memorial Award:
Rachel Schwartz and **Bernie May**
for their paper
"Genetic Evaluation of Isolated Populations for Use in Reintroductions Reveals Significant Genetic Bottlenecks in Potential Stocks of Sacramento Perch" in *Transactions of the American Fisheries Society* 137:1764-1777.

MARINE FISHERIES SECTION

Steven Berkeley Marine Conservation Fellowship:
Aleksandra Maljkovic

Honorable Mention:
Jack Kittinger and **Annie Schmidt**

PHOTOS: VISITPITTSBURGH & COMMONWEALTH MEDIA SERVICES

AMERICAN FISHERIES SOCIETY 140th ANNUAL MEETING

FINAL CALL FOR PAPERS

Kayaking on the Allegheny River

The setting for 140th Annual Meeting of the American Fisheries Society, along the banks of the Allegheny River in western Pennsylvania, is emblematic of the meeting's theme "Merging our Deeper Currents." From 12–16 September 2010, in Pittsburgh, Pennsylvania, at the confluence of the Allegheny and Monongahela rivers, the Pennsylvania Chapter of the American Fisheries Society and the Pennsylvania Fish and Boat Commission will host the incredible diversity of fisheries professionals from around the world who comprise AFS. President Don Jackson envisions this meeting, held at the David L. Lawrence Convention Center and the Westin Hotel, as a venue for participants to gain a more complete understanding of the broad and varied issues that unite us and that are needed to more fully advance the science that is the foundation of the Society. Pittsburgh is a renaissance city, a melting pot of cultures, and is characteristic of the aquatic systems in Western Pennsylvania. Here streams range from montane, brook trout headwater streams to large rivers with smallmouth bass, paddlefish, and catfish, and lacustrine habitats exhibit similar range of conditions from ephemeral pools to expansive reservoirs. Merging the waters of these assorted habitats into an integrated and functional system parallels the incredible challenges and opportunities for the members of the AFS. Pittsburgh provides that setting.


Paddlefish

FISHERIES MANAGEMENT CHALLENGES

From the early 1800s to the present, Pennsylvania coal and oil production has helped fuel the nation and the world. Although mining laws of the late 1900s now help to protect streams, over 5,000 legacy sites still degrade water quality and impact waters for fisheries and human uses. Recovering these areas is a long and tedious process, and may require perpetual maintenance of treatment facilities. Progress is being made to address these historical damages, but over 4,000 miles of mine-impaired waterways exist in the Commonwealth and considerable work remains.


Carnegie Museum of Natural History

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 sometimzes supplemented by posters. The Pittsburgh '10 Program Committee is considering following the example set at the Ottawa and Nashville meetings and allowing "Speed Presentations" coupled with posters to shorten the time required for symposia and enhance interactions. 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. Speed presentations serve, in essence, as "advertisements" for posters (and the people doing new and interesting work). They are an exciting new way to disseminate information and foster one-on-one interactions among symposium participants.

SYMPOSIA

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 8 January 2010. All symposium proposal submissions must be made using the AFS online symposium proposal submission form, which is available on the AFS website (www.fisheries.org). If you do not receive confirmation by 15 January 2010, please contact Dave Argent at (watershed@calu.edu). The Program Committee will review all symposium proposals and notify organizers of acceptance or refusal by 5 February 2010. If accepted, organizers must submit a complete list of all confirmed presentations and titles by 26 February 2010. Symposium abstracts (in the same format as contributed abstracts; see below) are due by 5 March 2010.

FORMAT FOR SYMPOSIUM PROPOSALS

Submit using AFS online symposium submission form.

When submitting your abstract include the following:

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 (oral and poster). State the time required for regular oral presentations (i.e., 20 minutes per speaker) and the time required for speed presentations and poster viewing (3 minutes per speaker plus 1 hour of 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 authors:** Please supply information in the following format:

Presenters:	1. _____
	2. _____
Tentative title:	1. _____
	2. _____
Confirmed: (yes/no)	1. _____
	2. _____
Format: (regular or speed)	1. _____
	2. _____
Name of presentation :	1. _____
	2. _____

10. **Sponsor(s), if applicable.**
(Note: A sponsor is not required.)
1. _____
2. _____

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 5 February 2010.
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 2010.

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 2010; register early for cost savings.

For information on how to construct a great poster, please take a moment to consult Carline (2007. Guidelines to designing posters. Fisheries 32[6]:306-307). The maximum allowable poster size will be 91 cm X 112 cm (36" x 44") in a landscape or portrait format.

FORMAT FOR SUBMITTED ABSTRACTS

For abstracts submitted to a Symposium

1. **Enter Symposium title:** _____
2. **Format:** (oral or speed) _____
(accompanied by poster)
3. **For abstracts submitted as a Contributed Paper:** Enter 2 choices for topic:
_____
_____
4. **Specify format:** Oral—preferred, or poster—acceptable) _____

For all abstracts

Title: An example abstract for the AFS 2010 Annual Meeting
Authors:
Hartman, Kyle. West Virginia University, 322 Percival Hall, Morgantown, West Virginia 26506; 304-293-4797; hartman@wvu.edu
Mazik, Patricia. USGS/West Virginia Cooperative Fish and Wildlife Research Unit, 322 Percival Hall, West Virginia University, Morgantown, West Virginia 26506; 304-293-4943; pmazik@wvu.edu
Presenter: Kyle Hartman
Abstract: Abstracts are used by the Program Committee to evaluate and select papers for inclusion in the scientific and technical sessions of the 2010 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) Student presenters must indicate if they wish their abstract to be considered for competition for a best presentation (i.e., paper or poster, but not both) award. If they respond "no," the presentation will be considered for inclusion in the Annual Meeting by the Program Committee, but will not receive further consideration by the Student Judging Committee. If students indicate "yes," they will be required to submit an application to the Student Judging Committee. Components of the application will include an extended abstract and a check-off from their mentor indicating that the study is at a stage appropriate for consideration for an award.

CONTACTS

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Organizing a Continuing Education course or workshop:
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CALENDAR: FISHERIES EVENTS

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

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

More events listed at www.fisheries.org.

Jan 20-22		**10th National Conference on Science, Policy, and the Environment: The New Green Economy**	
		Washington, DC	www.ncseonline.org/conference/greeneconomy
Feb 11-12		**Using Hydroacoustics for Fisheries Assessment**	
		Seattle, Washington	www.htisonar.com/at_short_course.htm
Feb 15-17		**Societal Applications in Fisheries and Aquaculture Using Remote Sensing: Remote Sensing and Fisheries**	
		Kochi, India	www.geosafari.org/kochi
Mar 1-5	AFS	**Aquaculture 2010**	
		San Diego, California	www.was.org
Jun 20-22	AFS	**Second International Catfish Symposium sponsored by AFS North Central and Southern Divisions**	
		St. Louis, Missouri	wwwcatfish2010.org
April 25-27	AFS	**66th Annual Northeast Fish and Wildlife Conference**	
		Newton, Massachusetts	www.neafwa.org
May 30-Jun 3	AFS	**AFS Early Life History Section's 34th Annual Larval Fish Conference**	
		Santa Fe, New Mexico	www.larvalfishcon.org
Jul 7-12		**Joint Meeting of Ichthyologists and Herpetologists**	
		Providence, Rhode Island	www.dce.ksu.edu/conf/jointmeeting/future.shtml
Jul 25-30		**Fisheries Society of the British Isles Conference: Climate Change and Fish**	
		Belfast, Northern Ireland	www.fsbi.org.uk/events.htm.

INDEX: FISHERIES 2009 VOLUME 34

[President's Hook] **Building Bridges for Community Development among Natural Resources Organizations.** Donald C. Jackson. 34(10):524,565.

[Director's line] **A Community of Professionals…** Gus Rassam. 34(9):453-462.

Exploring the Peer Review Process: What Is It, Does It Work, and Can It Be Improved? Dennis R. DeVries, Elizabeth A. Marschall, and Roy A. Stein. 34(6):270-279.

Factors Influencing Membership of USFWS and USGS Biologists in AFS. T. Bruce Lauber, Eric J. Taylor, and Barbara A. Knuth. 34(1):9-19.

[Guest Director's Line] **Field Biologists and Fighter Pilots, Unite!** Edward J. Peters. 34(6):304.

[Guest Director's Line] **Is a "Fishy" Retirement in your Future?** Carlos Fetterolf. 34(3):136-137.

[Students' Angle] **Join the Education Section: A Great Way to Become Involved in AFS!** Julianne E. Harris. 34(4):190-191.

[President's Hook] **Keeping Our Batteries Charged.** Donald C. Jackson. 34(10):472.

[President's Hook] **A Look at AFS Members...** William G. Franzin. 34(7):316-317.

Maintaining the Competitiveness of the American Fisheries Society Journals: An Assessment Based on Influence and Cost-Effectiveness. David A. Hewitt, Jason S. Link, David H. Wahl, Steven J. Cooke, Martha E. Mather. 34(12):598-606.

[President's Hook] **Merging Our Deeper Currents.** Donald C. Jackson. 34(9):420-462.

[Guest Director's Line] **The North American Freshwater Fish Standard Sampling Project: Improving Fisheries Communication.** Scott A. Bonar, Wayne A. Hubert, and David W. Willis. 34(7):340-344.

[President's Hook] **Recognizing Diversity in AFS.** William Franzin 34(2):56,93.

[Students' Angle] T**he Role of the Student Member in the AFS Fisheries Information and Technology Section.** Michael E. Colvin and Jeff Kopaska. 34(6):305-306.

[President's Hook] **Science and Policy.** William Franzin. 34(1):4.

[President's Hook] **Scientific Discipline and Courage.** Donald C. Jackson. 34(12):576.

[Director's Line] **Steven Berkeley Fellowship.** Gus Rassam. 34(10):508.

[Students' Angle] **Student Opportunities within the Equal Opportunities Section.** Robin L. DeBruyne. 34(10):512-513.

[Students ' Angle] **The Student Subsection of the Education Section of AFS.** Melissa R. Wuellner and Kristal N. Schneider. 34(1):44-45.

[President's Hook] **Thanks to Our Skilled and Talented Members for a Great Year!** William G. Franzin. 34(8):368,411.

[Guest Director's Line] **A Vision for Climate Services in NOAA.** Susan Solomon, Randall Dole, Richard Feely, Isaac Held, Wayne Higgins, Jeff Payne, Eileen Shea, Usha Varanasi, and Marian Westley. 34(12):607-609.

[President's Hook] **Whatever Happened to the Policy Statement on Economic Growth and Fish Conservation?** William G. Franzin. 34(3):108,135.

[Guest President's Hook] **What's Happening Across the Pond: Observations of the Institute of Fisheries Management 2008 Conference in Leeds, England.** Ron Essig. 34(4):160,196.

SOCIOECONOMICS

Abdicating Responsibility: The Deceits of Fisheries Policy. Daniel W. Bromley. 34(6):280-290.

Creating a Community Context for the Fishery Stock Sustainability Index. Steve Jacob and Michael Jepson. 34(5):228-231.

ANNOUNCEMENTS: JOB CENTER

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

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Salary: Full time positions based on an average of 12 sea days a month. Starting rates are $216 per sea day and $14.25 per land hour. Health/dental insurance, vacation, sick, and holiday benefits.
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Qualifications: A B.S. in marine biology or biology required. Own transportation. Must be U.S. citizen or Canadian citizen.
Contact: E-mail resume, references, list of biology courses, and cover letter detailing sea and fish experience to 32944@aisobservers.hrmdirect.coml. For more information see AIS, Inc. www.aisobservers.com or NMFS Fisheries Sampling Branch information at www.nefsc.noaa.gov/femad/fsb/.

M.S. or Ph.D. Assistantship in Fisheries/Aquatic Ecology, University of Illinois, Natural History Survey.
Salary: $17,000 per year including waiver of tuition .
Closing: 1 January 2010.
Responsibilities: Research topics are varied and flexible, but individuals with interests related to four projects are preferred (1) recruitment, behavior, physiology, reproductive strategies, and management of largemouth bass; (2) population ecology of muskellunge; (3) application of physiological approaches to stream restoration with Cory Suski; and (4) population and community ecology of Lake Michigan fishes with Sergiusz Czesny.
Starting dates: June through August 2010.
Qualifications: B.S. or M.S. in fisheries/aquatic ecology.
Contact: Send a cover letter, resume, copies of transcripts, GRE scores, and three letters of reference to David H. Wahl, University of Illinois, 1816 S. Oak Street, Champaign, Illlinois, 61820 217 7284400; d-wahl@illinois.edu. See www.inhs.uiuc.edu/fieldstations/kbs/KBS_research.html.

James R. Winton, Stewart W. Alcorn, Ronald J. Pascho, and Diane G. Elliott. ***Journal of Aquatic Animal Health*** 20:225-235. Purcell may be contacted at mpurcell@usgs.gov.

2008 Best Paper in the *North American Journal of Aquaculture*

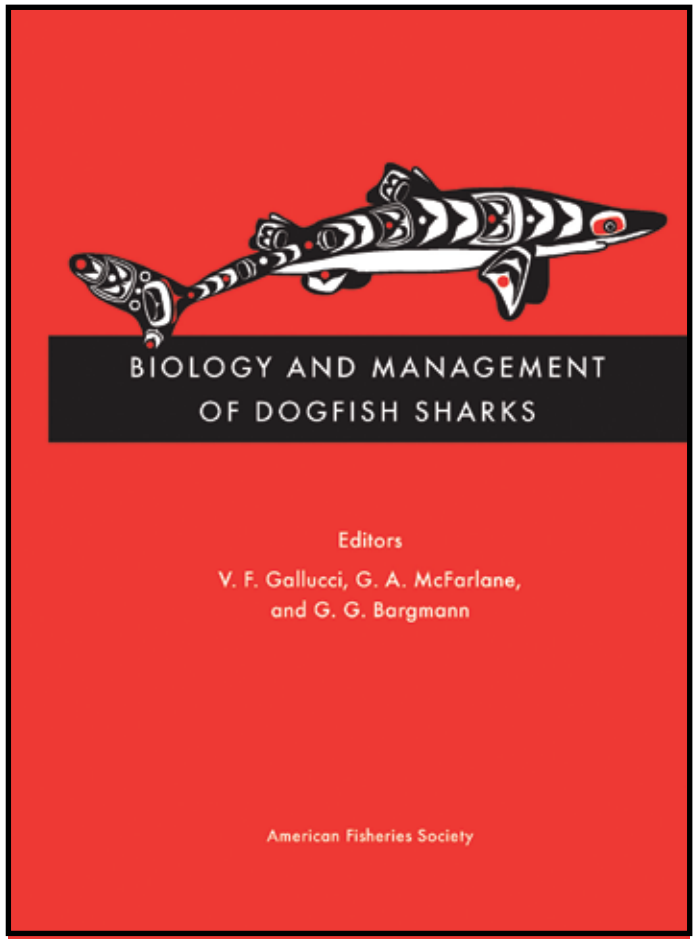
What do pelicans, snails, and worms have to do with a Mississippi catfish farmer's pocketbook? A lot, according to a recent award winning paper in the *North American Journal of Aquaculture* by three Mississippi State University researchers. More than 45,000 hectares (180 square miles) of northwestern Mississippi are used for catfish aquaculture ponds, supplying 55% of U.S. farm-raised catfish. In the late 1990s, a significant fish health problem arose from infestations of the trematode parasite *Bolbophorus*, which is carried by white pelicans. During various stages of its life cycle, the parasite sequentially infects the American white pelican, rams-horn snail, and channel catfish. Although the disease is widespread, the economic impact has not been addressed. When a catfish farm owner in 2004 requested that all of their ponds be tested for *Bolbophorus* and made available their production records, the researchers were able to fill in the crucial link between the rate of infection and the production impact. While uninfected ponds produced $1,526 per hectare in net returns, lightly infected ponds only produced $592/ha, and moderately and heavily infected ponds produced a net loss of up to -$1,123/ha. The authors suggest that farmers should test their ponds annually, closely examine poorly producing ponds, and break the parasite's life cycle by eliminating rams-horn snails from their ponds. **Farm-Level Economic Impacts of *Bolbophorus* Infections of Channel Catfish,** by *David J. Wise, Terrill R. Hanson, and Craig S. Tucker. North American Journal of Aquaculture* 70:382-387.Wise may be contacted at dwise@drec.msstate.edu.

BIOLOGY AND MANAGEMENT OF DOGFISH SHARKS

Vincent Gallucci, Gordon McFarlane, and Gregory Bargmann, editors

The spiny dogfish *Squalus acanthias* is one of the most abundant shark species in the world. For more than a century, it has been both reviled and valued, has supported commercial fisheries in the Pacific and Atlantic oceans, and has been overexploited in both. As the only shark species to recover from overfishing, its responses and recovery trajectories are of great interest to conservationists and fishery managers.

The book's 34 chapters compile current knowledge of dogfish, their ecology, and their management worldwide. It reviews historical fisheries, evaluates past and current management strategies, and provides new biological and ecological information from both the single species and ecosystems perspectives. It confirms the urgency of consideration of the human dimensions of management as part of efforts to protect dogfish where it is threatened while providing sustainable fisheries.



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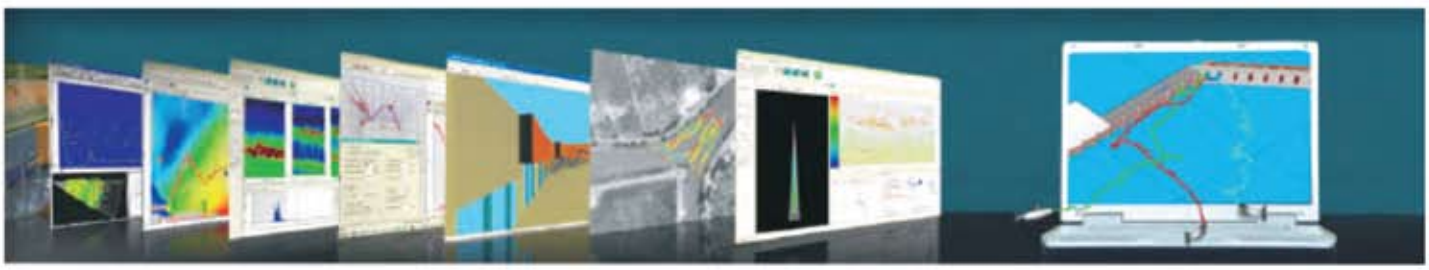

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