Native Fish Conservation Areas: A Vision for Large-scale Conservation of Native Fish Communities

Identification and Implementation of Native Fish Conservation Areas in the Upper Colorado River Basin
Community Ecology of Stream Fishes
Concepts, Approaches, and Techniques

Keith B. Gido and Donald A. Jackson, editors

Stream fish community ecology is an exciting field of research that has expanded rapidly over the past two decades. Both conceptual and technological advances have increased our ability to characterize patterns of community structure across multiple scales and evaluate processes that regulate those patterns. A main focus of this book is to synthesize those advancements and provide directions for future research.

Chapters are grouped into five main themes: macroecology of stream fishes, stream fish communities in landscapes—importance of connectivity, conservation challenges for stream fishes, structure and dynamics of stream fishes, and role of fishes in stream ecosystems. An international group of renowned authors have contributed chapters and theme summaries that provide examples of current research within each of five themes as well as ideas for new research directions.

664 pages, index, paper
List price: $79.00
AFS Member price: $55.00
Item Number: 540.73P
Published August 2010

TO ORDER:
Online: www.afsbooks.org
American Fisheries Society
c/o Books International
P.O. Box 605
Herndon, VA 20172
Phone: 703-661-1570
Fax: 703-996-1010
298  NEW MEMBERS

COLUMNS

265  PRESIDENT’S HOOK
New Frontiers in Fisheries Management and Ecology: Advancing Sound Science
There is concern among AFS members about the political rhetoric that is attempting to discredit science. As a professional scientific society our foremost response must be to assure that our scientific inquiry is beyond reproach.
Wayne A. Hubert

300  GUEST DIRECTOR’S LINE
Education in the Era of the Millennials and Implications for Future Fisheries Professionals and Conservation
How to prepare and support the next generation of fisheries professionals (the Millennials) to best focus on the future of fisheries conservation and management.
Kelly F. Millenbah, Bjørn H. K. Wolter, and William W. Taylor

UPDATE

266  LEGISLATION AND POLICY
Elden W. Hawkes, Jr.

FEATURE: FISHERIES MANAGEMENT

267  Native Fish Conservation Areas: A Vision for Large-Scale Conservation of Native Fish Communities
Conserving a network of functional native fish communities across the country would provide an ecologically and economically viable complement to current approaches to fisheries conservation.
Jack E. Williams, Richard N. Williams, Russell F. Thurow, Leah Elwell, David P. Philipp, Fred A. Harris, Jeffrey L. Kershner, Patrick J. Martinez, Dirk Miller, Gordon H. Reeves, Christopher A. Frissell, and James R. Sedell

FEATURE: CONSERVATION

278  Identification and Implementation of Native Fish Conservation Areas in the Upper Colorado River Basin
Native Fish Conservation Areas represent a proactive approach to fisheries management in the Upper Colorado River Basin where one set of management objectives target long-term persistence of entire native fish communities.
Daniel C. Dauwalter, John S. Sanderson, Jack E. Williams, James R. Sedell

STUDENT ANGLE

295  Fish Species Richness in Oxbow Lakes
To improve the ecological well-being of Delta oxbow lakes, research is in progress to determine variables that may influence the fish species richness.
Dan J. Dembkowski

NEWS

289  Fish & People
290  Units

296  RECENTLY CERTIFIED PROFESSIONALS

JOURNAL HIGHLIGHTS

297  North American Journal of Aquaculture, Volume 73, Number 2

298  NEW MEMBERS

ANNOUNCEMENTS

308  June 2011 Jobs

COVER: Native trout are good indicator species for potential native fish conservation areas. Here is a westslope cutthroat trout and friend.
CREDIT: Rick Williams
The American Fisheries Society (AFS), founded in 1870, is the oldest and largest professional society representing fisheries scientists. The AFS promotes scientific research and enlightened management of aquatic resources for optimum use and enjoyment by the public. It also encourages comprehensive education of fisheries scientists and continuing on-the-job training.

**AFS OFFICERS**
- **PRESIDENT**
  Wayne A. Hubert
- **PRESIDENT ELECT**
  William L. Fisher
- **FIRST VICE PRESIDENT**
  John Boreman
- **SECOND VICE PRESIDENT**
  Sarah Fox
- **PAST PRESIDENT**
  Donald C. Jackson
- **EXECUTIVE DIRECTOR**
  Ghassan “Gus” N. Rassam

**FISHERIES STAFF**
- **DIRECTOR OF PUBLICATIONS**
  Aaron Lemer
- **MANAGING EDITOR**
  Jesse Trushenski
- **SENIOR EDITOR**
  Ghassan “Gus” N. Rassam

**EDITORS**
- **SCIENCE EDITORS**
  Madeleine Hall-Arber
  Ken Ashley
  Steven Cooke
  Ken Currens
  Andy Danylchuk
  Andrew Fayram
  William E. Kelso
  Deidre M. Kimball
  Dennis Lassuy
  Daniel McGarvey
  Allen Rutherford
  Roar Sandodden
  Jeff Schaeffer
  Jesse Trushenski
  Jack E. Williams
  Jeffrey Williams

**BOOK REVIEW EDITORS**
- Francis Jaines
- Ben Letcher
- Keith Nislow

**ABSTRACT TRANSLATION**
- Pablo del Monte Luna

**2011 AFS MEMBERSHIP APPLICATION**

**AMEERICAN FISHERIES SOCIETY • 5410 GROSVENOR LANE • SUITE 110 • BETHESDA, MD 20814-2199**

**NAME__________________________**

**Address__________________________**

**City__________________________**

**State/Province ________ ZIP/Postal Code ________**

**Country__________________________**

**Please provide (for AFS use only) Phone__________________________**

**Fax__________________________**

**E-mail__________________________**

**DUES AND FEES FOR 2011 ARE:**

- **$80 in North America ($95 elsewhere)** for regular members,
- **$20 in North America ($30 elsewhere)** for student members, and
- **$40 ($50 elsewhere)** for retired members.

**FEES INCLUDE:**

- **$19 for Fisheries subscription.**
- Nonmember and library subscription rates are **$157 in North America ($199 elsewhere).**

Price per copy: **$3.50 member; $6 nonmember.**

Recruited by an AFS member? yes no

**EMPLOYER__________________________**

**Industry__________________________**

**Academia__________________________**

**Federal gov’t__________________________**

**State/provincial gov’t__________________________**

**Other__________________________**

**MEMBERSHIP TYPE/DUES (Includes print Fisheries and online Membership Directory):**

<table>
<thead>
<tr>
<th>Category</th>
<th>U.S.</th>
<th>Elsewhere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing countries I (Includes online Fisheries only)</td>
<td>$50</td>
<td>$54</td>
</tr>
<tr>
<td>Developing countries II: N/A NORTH AMERICA</td>
<td>$25</td>
<td>$30</td>
</tr>
<tr>
<td>Regular: $80 NORTH AMERICA</td>
<td>$95</td>
<td>$95 OTHER</td>
</tr>
<tr>
<td>Student (includes online journals): $20 NORTH AMERICA</td>
<td>$30</td>
<td></td>
</tr>
<tr>
<td>Young professional (year graduated): $40 NORTH AMERICA</td>
<td>$50</td>
<td></td>
</tr>
<tr>
<td>Retired (regular members upon retirement at age 65 or older): $40 NORTH AMERICA</td>
<td>$50</td>
<td></td>
</tr>
<tr>
<td>Life (Fisheries and 1 journal): $1,737 NORTH AMERICA</td>
<td>$1,737 OTHER</td>
<td></td>
</tr>
<tr>
<td>Life (Fisheries only, 2 installments, payable over 2 years): $1,200 NORTH AMERICA</td>
<td>$1,200 OTHER: $1,200</td>
<td></td>
</tr>
<tr>
<td>Life (Fisheries only, 2 installments, payable over 1 year): $1,000 NORTH AMERICA</td>
<td>$1,000 OTHER</td>
<td></td>
</tr>
</tbody>
</table>

**JOURNAL SUBSCRIPTIONS (Optional):**

<table>
<thead>
<tr>
<th>Journal</th>
<th>U.S.</th>
<th>Elsewhere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transactions of the American Fisheries Society</td>
<td>$25</td>
<td>$45</td>
</tr>
<tr>
<td>North American Journal of Fisheries Management</td>
<td>$25</td>
<td>$45</td>
</tr>
<tr>
<td>North American Journal of Aquaculture</td>
<td>$25</td>
<td>$45</td>
</tr>
<tr>
<td>Journal of Aquatic Animal Health</td>
<td>$25</td>
<td>$45</td>
</tr>
<tr>
<td>Fisheries InfoBase</td>
<td>$25</td>
<td>$45</td>
</tr>
</tbody>
</table>

**PAYMENT**

Please make checks payable to American Fisheries Society in U.S. currency drawn on a U.S. bank, or pay by VISA, MasterCard, or American Express.

<table>
<thead>
<tr>
<th>Payment Method</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td></td>
</tr>
<tr>
<td>VISA</td>
<td></td>
</tr>
<tr>
<td>American Express</td>
<td></td>
</tr>
<tr>
<td>MasterCard</td>
<td></td>
</tr>
</tbody>
</table>

**Signature__________________________**

**Account #__________________________**

**Exp. Date__________________________**

**Signature__________________________**

**American Fisheries Society • www.fisheries.org**

*Fisheries (ISSN 0363-2415) is published monthly by the American Fisheries Society; 5410 Grosvenor Lane, Suite 110; Bethesda, MD 20814-2199 © copyright 2011. Periodicals postage paid at Bethesda, Maryland, and at an additional mailing office. A copy of Fisheries Guide for Authors is available from the editor or the AFS website, www.fisheries.org. If requesting from the managing editor, please enclose a stamped, self-addressed envelope with your request. Republication or systematic or multiple reproduction of material in this publication is permitted only under consent or license from the American Fisheries Society. Postmaster: Send address changes to Fisheries, American Fisheries Society; 5410 Grosvenor Lane, Suite 110; Bethesda, MD 20814-2199.*

*Fisheries is printed on 10% post-consumer recycled paper with soy-based printing inks.*
New Frontiers in Fisheries Management and Ecology: Advancing Sound Science

Wayne A. Hubert

Ranting! You know what that is. All you have to do to experience it is turn on the radio and listen to a talk show. I don’t need to mention names, but some political commentators are making big bucks with this ugly behavior. It doesn’t make a difference if they have “conservative” or “liberal” perspectives, they rant. The dictionary defines ranting as extravagantly or violently speaking or disclaiming, talking in a wild or vehement way, raving. About the only time I listen to talk radio is when I drive across the open spaces of Wyoming. It is generally a long distance between towns and there is not much traffic, so I need something to keep me awake. Becoming irritated by nonsensical ranting is one solution to boredom.

You don’t have to listen to any of these talk shows for long before you hear the word belief or believe. It is usually a declaration like this, “Those _____ believe in ______.” Probably the most common references made by conservative commentators in recent years are directed at environmentalists in reference to climate change, “Those environmentalists believe in climate change.” Again, I resort to the dictionary to recall what it means to believe—to have confidence in something as the truth without absolute proof. Stop! What does this have to do with science?

Accumulated evidence lends credence to particular theories. Thus, we have strong evidence supporting some theories, such as gravity, the relativity of matter and energy, evolution via natural selection, and anthropogenic causes of climate change.

As scientists, we approach knowledge of the physical universe by systematic study, developing theories as to how things work and formulating hypotheses that test the theories, making observations or conducting experiments in defined ways to test hypotheses, and interpreting observations objectively with the intent of determining if they support or refute hypotheses. Accumulated evidence lends credence to particular theories. Thus, we have strong evidence supporting some theories, such as gravity, the relativity of matter and energy, evolution via natural selection, and anthropogenic causes of climate change.

We must assure that only sound scientific inquiry is published in our journals, that the highest levels of peer review and technical editing are applied to our journals, and that there is never a doubt as to the credibility of the information we publish. Those of us dealing in policy and management must resolve to use scientific information appropriately. Acknowledge risks, acknowledge the strength of evidence supporting particular policies or management actions, and acknowledge what we don’t know. In the long run, credible scientific information and objective interpretation of the information are our primary products.

In the dissemination of science-based information during meetings at all levels of the Society, let’s resolve to focus on the science. Make sure that oral presentations and posters are presented with credible science in mind. Clearly describe the theoretical base, the hypothesis or hypotheses being tested, the methods, and the results and objectively interpret the results acknowledging limitations. Let’s not allow presentations that represent poor science, are obviously biased, or promote a cause to be made without challenge. We have a responsibility as participants at meetings to point out less-than-credible research and discourage people from making such presentations or posters.

Continued on page 306
Budget Requests for Fisheries Programs in FY 2012

Cutting spending from the federal budget has been a hot topic in the 112th congress. Federal agencies will be forced to make tough choices to prioritize and identify cost-saving measures. Many cuts affect fisheries and fisheries related programs. All of the requested budget levels for FY 2012 are based on the enacted budget for FY 2010, due to the budget for FY 2011 not being approved in time. If the FY 2012 budget is enacted as requested, the Department of Interior (DOI) will see its budget levels remain the same, with a request of 12 billion for FY 2012, and the U.S. Department of Agriculture’s budget would increase to $145 billion compared to 2010’s enacted budget of $129 billion.

Within DOI, agencies will see varying effects. The U.S. Geological Survey will have an increase of $6.1 million from the 2010 enacted level of $1.1 billion. However, the total budget for existing programs decreases by $52 million, with a $42 million reduction from its core programs. This reduction includes an estimated $2.014 million in the fisheries program. Examples:

- The Fish Passage Program would decrease by $220,000.
- The Fish Drug Program will be eliminated due to its loss of $700,000 of funding.

In contrast, the Asian Carp Control Program’s budget will increase by $3 million.

Other increased funding is projected for various ecological restoration efforts conducted by USGS. These include:

- $4.6 million for the Chesapeake Bay
- $1.4 million for the Columbia River
- $3.5 million for the Great Lakes
- $1.5 million for Puget Sound

The Bureau of Land Management will see an agency wide reduction of $12 million, while its Fisheries Management and Threatened & Endangered Species Management programs face reductions of $411,000 and $644,000, respectively. The U.S. Fish and Wildlife Service will see an increase of $2.26 million, while its Fish and Aquatic Resource Conservation budget will see a decrease of $12.2 million.

Examples:

- A reduction of about $3.9 million from APHIS’ Aquaculture Program ($3.1 from its Viral Hemorrhagic Septicemia Program)
- The National Resource Conservation Service (NRCS) would also benefit from an elimination of its watershed programs.
- The Forest Service will see an increase to its Fisheries Program of $32,000.

Within the Department of Commerce, NOAA’s budget will increase by $749 million to $5.5 billion from FY 2010’s 4.75 billion. National Marine Fisheries Service’s (NMFS) budget escaped major cuts, only receiving a 1% decrease from 2010, including:

- $216.6 million for Protected Species Research and Management
- $476 million for Fisheries Research and Management
- $53.6 million for Habitat Conservation and Restoration
- $65 million for the Pacific Coastal Salmon Recovery Fund
- $67 million to expand annual stocks assessments for determining Annual Catch Limits.
- $3 million to improve the timeliness and quality of catch monitoring in recreational fisheries.
- $54 million to support the voluntary establishment of catch share programs.
- $8 million increase for the Species Recovery Grants Program.
- $5 million increase to support the restoration and protection of the Chesapeake Bay.

Final FY 2011 Continuing Resolution Includes Major Cuts

The seemingly endless battle over the 2011 fiscal year budget came to an end as the Senate, House of Representatives, and the White House finalized an agreement that funds the federal government for the remainder of FY 2011. This new continuing resolution would potentially cut an estimated $40 billion from the federal budget. These cuts will affect various government agencies and programs, including:

- $14 million in cuts to the Bureau of Land Management
- $136 million in cuts to the U.S. Fish and Wildlife Service
- $122 million in cuts to the National Park Service
- $48 million in cuts to the U.S. Geological Survey
- $41 million in cuts to the National Forest System
- $116 million in cuts to DOI Climate Change programs

The cuts will also eliminate NOAA funding that was allocated for the establishment of a Climate Service and to approve new catch share programs in certain fisheries. NOAA’s catch share programs, along with its other fisheries management tools, are widely seen as the reason for halting overfishing in the United States in 2010.
Native Fish Conservation Areas: A Vision for Large-Scale Conservation of Native Fish Communities

Jack E. Williams, Richard N. Williams, Russell F. Thurow, Leah Elwell, David P. Philipp, Fred A. Harris, Jeffrey L. Kershner, Patrick J. Martinez, Dirk Miller, Gordon H. Reeves, Christopher A. Frissell, and James R. Sedell

Jack Williams is the senior scientist for Trout Unlimited. Rick Williams is the conservation advisor for Federation of Fly Fishers; Thurow is a research fisheries scientist for the USDA Forest Service; Elwell is the program director for the Center for Aquatic Nuisance Species; Philipp is the principal scientist at the Illinois Natural History Survey; Harris is the former chief of inland fisheries for the North Carolina Wildlife Resources Commission; Kershner is the director of the U.S. Geological Survey’s Northern Rocky Mountain Science Center; Martinez is a nonnative fish coordinator for the U.S. Fish and Wildlife Service; Miller is the native trout coordinator for the Wyoming Game & Fish Department; Reeves is a research fish biologist for the USDA Forest Service; Frissell is the director of science and conservation for the Pacific Rivers Council; Sedell is the fisheries program director for the National Fish and Wildlife Foundation.

ABSTRACT: The status of freshwater fishes continues to decline despite substantial conservation efforts to reverse this trend and recover threatened and endangered aquatic species. Lack of success is partially due to working at smaller spatial scales and focusing on habitats and species that are already degraded. Protecting entire watersheds and aquatic communities, which we term “native fish conservation areas” (NFCAs), would complement existing conservation efforts by protecting intact aquatic communities while allowing compatible uses. Four critical elements need to be met within a NFCA: (1) maintain processes that create habitat complexity, diversity, and connectivity; (2) nurture all of the life history stages of the fishes being protected; (3) include a large enough watershed to provide long-term persistence of native fish populations; and (4) provide management that is sustainable over time. We describe how a network of protected watersheds could be created that would anchor aquatic conservation needs in river basins across the country.

INTRODUCTION

The diversity of North American freshwater biota continues to decline at a rapid rate. A recent assessment found that 39% of freshwater and diadromous fishes are at risk of extinction (Jelks et al. 2008). The trend of endangerment appears to be escalating. When comparing the conservation status of fishes included in the status review conducted in 1989 to the review conducted in 2008, 89% of taxa had deteriorated in condition, whereas only 6% had improved (J. E. Williams et al. 1989; Jelks et al. 2008). Declines in native fishes have been attributed to the obstruction of migratory pathways from dams, irrigation diversion, and channel modification; degradation of spawning and rearing habitat; angling mortality; and competition, predation, and hybridization with invasive species (Lee et al. 1997; Jelks et al. 2008).

Declines in freshwater fish status and distribution have continued despite our increased understanding of the life history requirements of these species and the implementation of some of the strongest environmental and species protection laws in the world. For instance, although the number of fish species listed pursuant to the Endangered Species Act has grown over the years, no fish species has been removed from the list due to recovery. To date, all fish delistings have been a result of either taxonomic revisions or extinctions (J. E. Williams et al. 2005). Though the Endangered Species Act has been an effective tool for preventing extinction, it has proven less effective at protecting entire ecosystems or protecting species before they become endangered (Doremus and Pagel 2001).

Collectively, agencies and other conservation entities spend vast monetary resources on endangered fish recovery and aquatic ecosystem restoration but realize relatively little for
these efforts. According to the U.S. Fish and Wildlife Service (USFWS 2010), federal and state governments spent more than $1.1 billion on threatened and endangered (T&E) species in the United States during fiscal year 2008. Nine of the top 10 T&E species expenditures are for fishes (including pallid sturgeon, Pacific salmon and steelhead, and bull trout), and 46 of the top 60 T&E species expenditures are for aquatic species (USFWS 2010). An additional $1 billion is spent annually on river restoration in the United States (Bernhardt et al. 2005).

Species declines in aquatic ecosystems are not limited to fishes. More than two of three species of freshwater mussels are at risk of extinction (J. D. Williams et al. 1993), and nearly half of all freshwater crayfishes in the United States and Canada are at risk (Taylor et al. 2007). Extinction rates are five times higher for freshwater fauna in the United States than for mammals, birds, or other terrestrial species (Bernhardt et al. 2005). Additionally, Master et al. (2000) further support the contention that aquatic biodiversity in North America has declined precipitously in recent decades and that aquatic species are at greater risk than their terrestrial counterparts (Figure 1).

Furthermore, threats to aquatic biodiversity appear to be accelerating due to four primary factors: increasing freshwater demand for a growing human population (Postel 2000; Deacon et al. 2007), wildland development and conversion (Hudy et al. 2008), spreading invasive species (U.S. Environmental Protection Agency [USEPA] 2008), and rapid climatic change (Poff et al. 2002; Haak et al. 2010). There is also increasing evidence for a synergy among these factors, especially invasive species and climate change, which would result in new invasion pathways and more rapid spread of invasive species (Rahel and Olden 2008).

Traditional conservation approaches have been only moderately effective at protecting aquatic species for a variety of reasons. Fundamentally, the linear shape of riverine systems and the interconnectedness of drainage systems provide sub-
stantial challenges to protection efforts that are usually based on terrestrial features and land ownership boundaries rather than on watershed boundaries. On the other hand, lakes and reservoirs, which in many cases could serve as important aquatic diversity areas, often have been subjected to numerous fish introductions and may be dominated by nonnative species (Li and Moyle 1993; Adams et al. 2001).

Many conservation strategies are more reactive than proactive, focusing on saving individual species or restoring already degraded habitats. Despite being more ecologically and economically effective, we rarely seek to protect intact ecosystems and entire communities before their components become threatened (J. E. Williams et al. 1989).

Existing threats have encouraged fisheries managers to establish small, isolated stream reaches as refuge areas for rare native fishes, especially native trout. These fragmented habitats may be at severe risk in a future likely to be characterized by increasing frequency and severity of stochastic disturbances (J. E. Williams et al. 2009). For example, small population sizes and a lack of connectivity increase extinction risk in these isolated populations (Hilderbrand and Kershner 2000). Indeed, small population size and increasing wildfires already have combined to cause population losses in Gila trout (Brown et al. 2001).

The current status of aquatic species signals the need for additional strategies for conserving and restoring aquatic biodiversity. In response to this need, we propose a new watershed-scale approach, termed “native fish conservation areas” (NFCAs) to conserve and restore aquatic communities. Such an approach would protect existing strongholds of native species diversity and strive to restore a larger network of strongholds in conjunction with existing fish conservation efforts focused on individual species. We revisit the fish refuge concept, describe various alternatives for its implementation, and in a companion paper (Dauwalter et al., 2011), provide examples of how NFCAs can be implemented to integrate the needs of both coldwater and warmwater fishes. We argue that an integrated NFCA approach will provide a more cost-effective and sustainable method for conserving aquatic biodiversity in the face of growing challenges from water demand, land conversion, invasive species, and climate change.

A BRIEF HISTORY OF WATERSHED-SCALE FISH CONSERVATION

The concept of large-scale fish refuges dates back to 1892. During that year, President Harrison created the first Pacific salmon refuge on Afognak Island, Alaska. It later served as an egg source for a hatchery, but the refuge was closed in 1923 because fish culturists claimed that hatcheries were more efficient salmon producers than wild rivers (Lichatowich 1999).

Efforts to protect salmon and steelhead stimulated additional watershed-scale fish conservation efforts during development of the Northwest Forest Plan. In 1994, the U.S. Forest Service and U.S. Bureau of Land Management (BLM) established a series of key watersheds and riparian reserves along perennial and intermittent streams on federal lands in the Pacific Northwest. In the 10 years since implementation of protective measures, and despite significant increases in wildfire activity, 64% of 250 watersheds and riparian habitats improved in condition (Reeves et al. 2006). Although private lands were not included in the Northwest Forest Plan, Forest Service and BLM managed lands were sufficiently large and contiguous to facilitate successful efforts at watershed-scale management.

In California, Moyle and Yoshiyama (1994) proposed establishing a system of aquatic diversity management areas (ADMA) to help reverse the decline of that state’s native fish fauna. As part of the Sierra Nevada Ecosystem Project, Moyle (1996) proposed a series of 42 watershed-scale ADMA, whose primary goal would be the protection of aquatic biodiversity. The criteria for selection were watershed size (>50 km²), the presence of a natural hydrologic regime, the presence of native fishes and amphibians, and representativeness. Although not formally adopted, the ADMA concept was driven by the realization that some streams in the state still support much of their historic complement of native fishes. Keeping these systems intact would reduce the risk of extinguishing aquatic species as California’s human population and its demands on water resources continue to grow (Moyle and Yoshiyama 1994; Moyle 1996).

In a similar vein, Suski and Cooke (2007) argued for the establishment of freshwater protected areas as an alternative to current management approaches. These protected areas would provide larger watersheds where ecosystem processes needed to sustain aquatic and riparian habitats would be protected and where disturbances to aquatic systems could be minimized. Re-

<table>
<thead>
<tr>
<th>Benefits of implementing conservation strategies at broader watershed scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourages cooperation and coordination across multiple agency jurisdictions</td>
</tr>
<tr>
<td>Encourages integration of public and private land management efforts</td>
</tr>
<tr>
<td>Encourages a more comprehensive but also adaptive approach to nonnative species control</td>
</tr>
<tr>
<td>Focuses on maintaining or restoring ecosystem processes</td>
</tr>
<tr>
<td>Reduces dependency on species-specific management programs</td>
</tr>
<tr>
<td>Creates larger conservation areas that are more resilient to impacts of climate change</td>
</tr>
<tr>
<td>Encourages monitoring and adaptive management to deal with future uncertainty</td>
</tr>
<tr>
<td>Encourages development of environmentally sensitive ranching, farming, recreation, and other compatible uses</td>
</tr>
</tbody>
</table>
Regardless of the terminology, numerous authors have recognized the failure of current management practices to reverse the rapid decline in aquatic biodiversity and argued for watershed-scale approaches to protect remaining native fish assemblages (J. E. Williams et al. 1989; Moyle and Yoshiyama 1994; Frissell and Bayles 1996; Suski and Cooke 2007).

**Defining Native Fish Conservation Areas**

In April 2008, a two-day symposium was hosted in Boise, Idaho, by Trout Unlimited, the Federation of Fly Fishers, and the Fisheries Conservation Foundation to gather fisheries scientists, resource managers, policy makers, and nongovernmental conservation organizations to discuss new approaches for conserving native fishes and aquatic ecosystems at watershed scales. Impetus for the symposium came initially from the Federation of Fly Fishers, where Rick Williams and colleagues (Lichatowich and Williams 2004; R. N. Williams and Tabbert 2005) wrote a series of articles exploring the concept of native fish refuges for salmon, steelhead, trout, and warmwater species conservation. The symposium resulted in a consensus definition for a native fish conservation area and development of a four-page prospectus that described the NFCA concept and how it might be implemented (available at http://www.tu.org/science/science-team-csi-reports). The concept is very similar to aquatic diversity management areas, which have been proposed by Peter Moyle and his colleagues as a way to conserve aquatic biodiversity in California (Moyle and Yoshiyama 1994).

We define a native fish conservation area as a watershed-scale (fifth-level, 10-digit HUC or larger) area where management emphasizes conservation and restoration for long-term persistence of native fishes and other native aquatic species while allowing compatible uses. Fifth-level watersheds vary in size from about 16,000 to 101,000 ha (U.S. Geological Survey and U.S. Department of Agriculture Natural Resources Conservation Service 2009). The NFCA concept does not replace more traditional approaches to fisheries conservation but instead complements existing efforts that are often more reactive to existing stressors and focused on single species rather than larger communities. Establishment of watershed-scale conservation areas would conserve the biological integrity of native fish populations as well as the larger aquatic ecosystems upon which those fishes depend. The size of watersheds included in individual NFCAs would be dependent on a variety of factors but should primarily be driven by the needs of the specific aquatic system and its native fish community, rather than extrinsic factors such as jurisdictional boundaries and ownerships.

There are several economic and ecological efficiencies to managing and restoring entire fish communities at watershed scales rather than managing individual species at local streams. As described earlier, agencies in the United States spend billions of dollars annually recovering endangered species and restoring degraded ecosystems but relatively little in protecting species’ assemblages that still are intact and habitats that still are healthy. Costs associated with protecting entire communities in a single watershed are likely to be less than the comparative cost of protecting individual species in discrete habitats. There also are likely to be economic efficiencies in conducting restoration at watershed scales. Among the chief causes of aquatic ecosystem restoration failure are the lack of a watershed-scale perspective and a tendency to focus on symptoms of the problem rather than treating the root cause of the problem, which is often related to working at smaller spatial scales (J. E. Williams et al. 1997). Some of the ecological benefits of working at these larger spatial scales are described in Table 1.

Figure 2. Idaho’s Middle Fork Salmon River is well known as a wilderness river and native fish stronghold and would have potential as an NFCA. Photo by Rick Williams.
are managed for reduced harvest. As Thurow et al. (1997) observed, native salmonids have generally persisted in the areas least influenced by humans. Within the western United States, the strongest and most intact native salmonid populations occur within a network of federally protected and managed lands, such as roadless areas, wilderness areas, wild and scenic rivers (e.g., westslope cutthroat trout, redband trout, and bull trout in Idaho’s Selway and Middle Fork Salmon rivers; Lee et al. 1997), and national parks (e.g., westslope cutthroat trout in Glacier National Park, Yellowstone cutthroat trout in Yellowstone National Park, and greenback cutthroat trout in Rocky Mountain National Park; Young 1995; Figures 2 and 3). Remaining strongholds for native eastern brook trout are found primarily in the Green Mountain and White Mountain National Forest lands and in the large, privately owned northern forest tracts in the upper New England states.

Flexibility and innovation may be key ingredients to establishing NFCA’s across lands of mixed ownership. The concept of establishing reserves for native fishes may cause concern that other uses, such as timber harvest, mining, grazing, other agricultural uses, and recreation, would be restricted. A central part of the vision for NFCA’s is that recreation and certain other multiple uses can be compatible with native fish conservation efforts. That said, because the primary reason for the NFCA is to protect the native fish populations and their habitats, decisions regarding compatible uses should be made based on their expected effects on the native fish community and the aquatic ecosystem. Local habitat conditions, land ownerships, stakeholder concerns, and other factors will also influence decisions regarding compatible uses. If streams and riparian areas are afforded special management protection and—depending on landscape and hydrologic conditions—numerous activities (including livestock grazing, timber harvest, prescribed burns, and other forms of vegetation), management can be compatible with native fish management.

Working successfully across watersheds containing various agency administrators and landowners will require patience, collaboration, innovation, vision, and strong leadership. Wonderleek and Yaffee (2000) describe the challenges of landscape collaborative conservation efforts across the United States, including some notably successful efforts that focus on rivers and their fisheries, such as Montana’s Blackfoot Challenge and Idaho’s Henrys Fork. Collaborative efforts work when they are mutually beneficial to all parties. Finding common ground is essential but can take time and effort. Nonetheless, in many parts of the country where large blocks of public lands are limited or lacking entirely, the ability of fisheries managers to forge mutually beneficial relationships with private landowners may prove essential to implementing the NFCA concept.

**Essential NFCA Components**

Four critical elements need to be met within a NFCA—

---

**Figure 3. Map of Middle Fork Salmon River drainage.**
three that will ensure its biological effectiveness and one that will ensure that the area is sustainable socially and institutionally—(1) protect and, if necessary, restore watershed-scale processes that create and maintain freshwater habitat complexity, diversity, and connectivity; (2) nurture all of the life history pathways of the fish species being protected; (3) include a large enough watershed to provide for long-term persistence of native fish populations; and (4) provide management that is sustainable over time.

**Maintain Natural Processes**

Aquatic habitats are dynamic over space and time and are shaped by processes occurring within their immediate stream valleys and upstream watersheds. Factors that create habitat complexity, diversity, and connectivity in aquatic systems often originate in headwater streams and intermittent channels far upstream from native fish communities. For example, interactions between stream flow and sediments, substrates, and large woody debris inputs create deep pool habitats and channel complexity. The NFCA should be based on watershed boundaries that include sufficient upslope lands and upstream waters to provide for the continuation of these processes over time.

Disturbances such as floods, drought, and wildfire may substantially alter the condition of streams and their watersheds and should be a consideration in defining the extent of NFCA (Reeves et al. 1995; Dunham et al. 2002). Therefore, it may be prudent to include a sufficiently large stream network so that the entire NFCA is less likely to be impacted by a single disturbance event, and fish would be more likely to have access to undisturbed habitats.

**Include Habitats for Diverse Life Histories and Life Stages**

To meet this second critical element, an NFCA must include habitats that are necessary for a species to express all major life history forms that were historically present. Consequently, an important initial step in assessing the suitability of an area as an NFCA might be to assess a species potential historical range, the life history forms that were present, and the current habitat conditions within the historical range. If suitable habitats exist to support all life history forms, an NFCA could be established for fish conservation and restoration of migratory corridors as well as spawning and rearing areas will be essential.

**Support Long-Term Population Persistence**

The NFCA should not only be large enough to support all life history stages of the native fishes but also to support sufficiently large populations that have a high likelihood of long-term persistence. At a minimum, Hilderbrand and Kershner (2000) recommend that sufficient habitat is needed to support an effective population size of 500 interbreeding adults to meet persistence needs in trout populations. For cutthroat trout (Oncorhyncus clarkii), an effective population of 500 equates to a census population of about 2,500 fish >75 mm total length. Dunham and Rieman’s (1999) work on bull trout (Salvelinus confluentus) suggested that a minimum habitat patch size of 5,000 ha was necessary for persistence. Trout populations occupying less than 5,000 ha of habitat may still meet persistence criteria if the following combinations of stream habitat availability and population density are available: 9.3–13.9 km stream habitat with high-density fish population (>93 fish/km) or 13.9–27.8 km habitat with moderate density population (31–93 fish/km; Hilderbrand and Kershner 2000). Although these values were derived for western trout populations, they may provide general guidance for other native fishes. If the goal is to support a metapopulation or to provide interconnected habitat patches, a larger amount of habitat would be needed.

**Manage in Perpetuity**

Management plans or other agreements should be in place to ensure that the NFCA will be managed in a manner that sustains aquatic and riparian habitat integrity over time and across management jurisdictions and land ownerships. Depending on the size and complexity of the watershed, this may require local community commitments, landowner agreements, and local and state government support.

Given variation in ecological value, all lands within the NFCA may not require equal protection or management intensity. If all lands within the watershed are not in some form of protective management, their management should at least be consistent with conservation of the aquatic and riparian habitats and the processes that shape these environments. Public lands, often located in higher elevation headwaters, may be more easily protected and have wider riparian buffers than are valley bottoms, which may be in private ownership.
However, it may be the lower elevation lands that historically harbored the larger and more diverse stream communities. The site-specific and watershed-specific contexts will be crucial in determining management needs and restoration priorities.

**IMPLEMENTING THE CONCEPT**

A variety of paths exist to implement the NFCA concept. A companion paper in this issue of *Fisheries* describes an approach for implementing the NFCA concept that focuses on cooperative management across diverse land ownerships (Dauwalter et al., 2011). An alternative approach to establishing NFCAs would be through formal refuge designation by a public land management agency. Though we emphasize the importance of implementing the concept over the vehicle of that implementation, it may be helpful to examine some implementation options, constraints, and opportunities.

Some watersheds are protected by existing formal designations but are not necessarily recognized for native fish conservation or specifically managed for these resources. For example, Idaho’s Middle Fork Salmon River and its native fish community are protected as part of the larger Frank Church River of No Return Wilderness. The Middle Fork is also designated as a Wild and Scenic River where angling for native cutthroat and bull trout is allowed under catch-and-release regulations.

As part of the Steens Mountain Cooperative Management and Protection Act of 2000, congress created the Donner und Blitzen Redband Trout Reserve on BLM lands in southeastern Oregon. According to the Act, the purposes of the Reserve are “to conserve, protect, and enhance the Donner und Blitzen population of redband trout and the unique ecosystem of plants, fish, and wildlife of a river system” (§302 of the Act). With the headwaters of the Donner und Blitzen River in a designated wilderness area, the drainage serves as an example where conservation efforts effectively protect an intact native fish community (Figures 4 and 5).

In California, the Yurok Tribe is planning a tribal park along Blue Creek, a major tributary of the lower Klamath River that provides habitat for coho salmon, steelhead, coastal cutthroat trout, and other native fishes. The intent of the Yurok Tribal Council is to restore the watershed and its native species “to the richness, diversity, and abundance provided by the Creator” (Yurok Tribe 2005:6). Western Rivers Conservancy recently purchased 10,117 ha in the lower Blue Creek drainage for restoration as part of the tribe’s park. These lands, when combined with the headwaters of Blue Creek in the Siskiyu

---

**Figure 4.** Oregon’s Donner und Blitzen River, which is managed as a native redband trout refuge by the Bureau of Land Management. Photo by Dan Dauwalter.

**Figure 5.** Map of Donner und Blitzen River drainage.
Wilderness Area of the Six Rivers National Forest, will place nearly the entire drainage area in conservation management (Figures 6 and 7).

Of course, mere protection of intact watersheds does not necessarily equate to a flourishing native fish community. Yellowstone Lake and its tributary streams are protected in Yellowstone National Park, yet the formerly robust and diverse populations of native Yellowstone cutthroat trout have been devastated by introduced lake trout and whirling disease (Koel et al. 2007). Even national park status and stewardship by the National Park Service does not ensure that aquatic ecosystems will be secure. A dedicated focus of management and monitoring of aquatic ecosystem integrity is needed in tandem with habitat protection measures.

The mission of the National Wildlife Refuge (NWR) System is to protect our nation’s fish and wildlife resources, and the system has been remarkably successful for many species and habitats, such as waterfowl and wetlands. Individual refuge parcels, however, often do not cover watershed-scale areas and can be problematic for protection of ecosystems and their diversity (Scott et al. 2004; Herbert et al. 2010). Many NWRs are designed to protect wetland-dependent species or migratory waterfowl that can flourish in disconnected habitat patches. Relative to fish conservation, national wildlife refuges have been more successful in protecting localized spring- or cave-dwelling fishes rather than riverine species that range over larger areas. For instance, Nevada’s Ash Meadows NWR was designated to protect a number of rare spring-dwelling species even though managers now realize that additional protection of groundwater aquifers, which extends well beyond refuge boundaries, is also needed (Deacon et al. 2007). Protecting rivers and their native fishes has proven more problematic within NWRs, which are seldom if ever designed around watershed boundaries. Even NWRs established along rivers, such as the Illinois River National Wildlife and Fish Refuge, consist of individual tracts of lands along rivers with little integration of their management to the broader watershed.

Even if NWRs do not provide sufficient lands to protect important watershed processes, they could anchor future NFCAs. The upper Androscoggin River along the Maine–New Hampshire border could be a potential NFCA in the east, where public lands are more scattered and less available to support watershed-scale NFCAs. Umbagog Lake, Rapid River, and the Magalloway River support native fish communities within the upper Androscoggin, and lands around Umbagog Lake are mostly within the Umbagog NWR (Figure 8).

Regardless of the densities of public lands in the region, managing for native fish communities will be particularly difficult if protected lands are scattered along river systems without regard to watershed boundaries and/or the potential for nonnative fish immigration. Even large national parks, such as Canyonlands and the Grand Canyon, which contain large stretches of natural riverine habitats, are not immune from invasion by nonnative species and upstream management practices. The Green and Colorado rivers in Canyonlands National Park, which historically provided excellent habitat for native big river fishes such as razorback sucker and Colorado pikeminnow, are now dominated by carp, channel catfish, and other nonnative aquatic species (J. E. Williams and Davis 1996). Recent studies have shown that up to 95% of the fishes in Canyonlands are nonnatives (http://www.nps.gov/cany/naturescience/fish.htm). Similarly, native fishes in the Colorado River in Grand Canyon National Park declined significantly in abundance because of cold, clear water releases from Glen Canyon Dam, located upstream from park boundaries (Kaeding and Zimmerman 1983).

Negative influences from adjacent lands can be a problem for both large and small reserves. The small size of many NWRs renders their ability to protect species almost entirely dependent upon processes and events occurring on adjacent lands (Czech 2005). Water is a particularly difficult resource
to manage, especially if water sources in headwaters are not protected. Pringle (2000) reported that 150 out of 224 western NWRs have conflicts with other water users, and only 98 of 224 reported that their existing water rights assured delivery of adequate water in an average water year.

Designing new NFCAs along watershed boundaries could provide a considerable conservation boost to native aquatic species. Where designation of entire watersheds as protected areas is impractical, management across various land ownerships could be more formally coordinated for the benefit of aquatic ecosystems (Dauwalter et al., 2011). In these cases, protected public lands could anchor conservation needs in critical parts of the watershed and cooperative agreements, easements, or other means could provide management focused on aquatic systems on private lands.

In addition to establishing new NFCAs, effort should be focused on restoring native fish communities in areas that are already protected. The National Park Service, for example, is emphasizing control of nonnative lake trout and rainbow trout in their efforts to reestablish native trout and grayling in Yellowstone National Park. If lake trout can be controlled in Yellowstone Lake, myriad aquatic and terrestrial species would benefit by restoration of Yellowstone cutthroat trout that historically numbered in the millions and ascended dozens of tributary streams from the lake each spring. Similar opportunities exist in other national parks and monuments where lands already are protected.

Protection of large tracts of land has been a cornerstone in the efforts to conserve terrestrial species, but has seldom been utilized to conserve aquatic species. Establishing a network of protected watersheds in river basins across the country will be challenging because of diverse patterns of land ownership, as well as land use, water allocation, and aquatic invasive species that dominate many areas. Nonetheless, the task will only become more difficult in the future as human population growth and associated demands on resources proceed. Conserving a network of functional aquatic communities across the country using the native
fish conservation area strategy would provide an economically and ecologically viable complement to current approaches to fish conservation.

ACKNOWLEDGMENTS

We thank Peter Moyle for his pioneering efforts to promote the conservation of larger aquatic communities. Many of the participants in the Boise workshop are authors of this article. Several others participated in the workshop and provided guidance to this effort, including John Epifanio (Illinois Natural History Survey), Chris Wood (Trout Unlimited), and Amy Haak (Trout Unlimited). Sabrina Beus kindly created the maps of potential NFCAs. We also appreciate comments from Dan Dauwalter (Trout Unlimited) and John Sanderson (The Nature Conservancy). Support for the workshop and subsequent efforts to promote Native Fish Conservation Areas have been provided by Trout Unlimited's Coldwater Conservation Fund, the Fisheries Conservation Foundation, Federation of Fly Fishers, and the National Fish and Wildlife Foundation. The authors also thank three anonymous reviewers for their helpful comments and suggestions.

REFERENCES


Moyle, P. B. 1996. Potential aquatic diversity management areas. in Sierra Nevada Ecosystem Project, volume 2, pp. 1493-1502 in Assessments and scientific basis for management options. University of California, Davis, Centers for Water and Wildland Resources.


Pringle, C. M. 2000. Threats to U.S. public lands from cumulative hydrologic alterations outside of their boundaries. Ecological Ap-


Identification and Implementation of Native Fish Conservation Areas in the Upper Colorado River Basin

Daniel C. Dauwalter
Research Scientist, Trout Unlimited, Boise, Idaho

John S. Sanderson
Water Program Director and Senior Freshwater Ecologist, The Nature Conservancy of Colorado, Fort Collins, Colorado

Jack E. Williams
Senior Scientist, Trout Unlimited, Medford, Oregon

James R. Sedell
Director of Fish Conservation, National Fish and Wildlife Foundation, Portland, Oregon

ABSTRACT: Freshwater fishes continue to decline at a rapid rate despite substantial conservation efforts. Native fish conservation areas (NFCAs) are a management approach emphasizing persistent native fish communities and healthy watersheds while simultaneously allowing for compatible human uses. We identified potential NFCAs in the Upper Colorado River Basin in Wyoming—focusing on Colorado River cutthroat trout (Oncorhynchus clarkii pleuriticus), flannelmouth sucker (Catostomus latipinnis), bluehead sucker (Catostomus discobolus), and roundtail chub (Gila robusta)—through a process that combined known and modeled species distributions, spatial prioritization analysis, and stakeholder discussions. The network of potential NFCAs is intended to serve as a funding framework for a National Fish and Wildlife Foundation (NFWF) Keystone Initiative focused on Colorado River Basin native fishes. We discuss current opportunities for and impediments to implementing the potential NFCAs. We identified for the NFWF Initiative over the long term. NFCAs represent a promising approach to fisheries management that complements existing approaches by focusing on persistent native fish communities.

INTRODUCTION

Despite substantial resources being allocated to conservation of freshwater ecosystems, freshwater fishes in North America are continuing to decline at a much faster rate than their terrestrial counterparts (Master et al. 2000; Jelks et al. 2008). Williams et al. (2011, this issue) discuss how current conservation approaches, such as the National Wildlife Refuge system, have only been moderately successful at protecting riverine ecosystems because rivers are linear in nature and approaches based on terrestrial features and land ownership fail to consider watershed boundaries that are fundamental to aquatic conservation (e.g., Roux et al. 2008).

Though others have proposed protecting watershed-scale areas for aquatic conservation (Saunders et al. 2002), Williams et al. (2011, this issue) proposed the concept of native fish conservation areas (NFCAs) where entire watersheds are cooperatively managed for native fish communities. As a complement to existing conservation approaches (e.g., headwater isolation; Novinger and Rahel 2003), implementation of NFCAs would emphasize habitat diversity and connectivity resulting from natural ecosystem processes, care for all life stages of focal species, large watersheds that facilitate long-term community persistence, and sustainable long-term management. The size of watersheds managed as an NFCA would be dependent on the aquatic ecosystem and native fish community rather than jurisdictional boundaries and ownerships.

Although many North American freshwater fishes are declining, the fish fauna native to the Colorado River Basin is especially imperiled (Minckley and Deacon 1968; Minckley et al. 2003). Only 14 fish species are native to the Upper Colorado River Basin (above Glen Canyon Dam), and 10 are endemic (Carlson and Muth 1989). At least 7 of the 10 endemic
species are imperiled. Four large-river species are listed as endangered: razorback sucker (Xyrauchen texanus), bonytail (Gila elegans), humpback chub (Gila cypha), and Colorado pikeminnow (Ptychocheilus lucius). Over 60 nonnative fishes have been introduced, and some are known to compete and hybridize with or prey upon native fishes (Olden et al. 2006). Substantial resources have been directed toward native fish survival and recovery. Nonnative fish removal programs have been implemented (Mueller 2005), and hatchery programs continue to propagate native fish to supplement wild populations (Schooley and Marsh 2007). In 2008, over US$26 million were spent on recovery of the four endangered species (U.S. Fish and Wildlife Service [USFWS] 2010). Despite these efforts, none have been delisted, and all remain at a high risk of extinction.

Four other species are not listed but are considered sufficiently at risk to warrant multistate conservation agreements: Colorado River cutthroat trout (Oncorhynchus clarkii pleuriticus), flannelmouth sucker (Catostomus latipinnis), bluehead sucker (Catostomus discobolus), and roundtail chub (Gila robusta; Colorado River cutthroat trout (CRCT) Coordination Team 2006; Utah Department of Natural Resources [UDNR] 2006). These nonlisted fishes native to the Colorado River Basin have received far less attention and resources compared to the endangered fishes. Although the Colorado River cutthroat trout is a sport fish, only 8% of its historic range is occupied by ecologically significant populations (unhybridized or having migratory life histories), with their decline due to habitat alteration and fragmentation and nonnative trout invasions (brook trout Salvelinus fontinalis, brown trout Salmo trutta, rainbow trout Oncorhynchus mykiss, and nonnative cutthroat trout subspecies; Young 2008). Flannelmouth sucker, bluehead sucker, and roundtail chub now occupy less than half of their historical ranges in the Upper Colorado River Basin (Bezzerides and Bestgen 2002). The native suckers have historically lacked management attention because they were often considered to be habitat generalists tolerant of environmental disturbances and competitors to sport fishes (Cooke et al. 2005). Past efforts were even made to remove them from rivers prior to reservoir impoundment, as was the case when 700 km of the Green River and its tributaries were treated with rotenone prior to the impoundment of Flaming Gorge Reservoir (Holden 1991; Wiley 2008).

Native fish conservation areas provide a useful management approach for the Upper Colorado River Basin because several conservation objectives can be accomplished in NFCAs that are extremely difficult or impossible on large rivers. Though management has emphasized endangered species recovery in the large rivers, NFCAs provide an opportunity to link the conservation of headwater trout populations with the medium-size streams that provide habitat for flannelmouth sucker, bluehead sucker, roundtail chub, and other native species. Most cutthroat trout populations are isolated in small headwater streams. NFCAs are managed to provide interconnected habitats that can increase population persistence by facilitating natural metapopulation processes (Dunham and Riemann 1999; Hilderbrand and Kershner 2000; Compton et al. 2008). At the same time, NFCAs can provide a discrete hydrologic unit in which native fish communities can be isolated, if needed, from nonnative invaders downstream (Novinger and Rahel 2003; Fausch et al. 2009; Clarkson and Marsh 2010). Likewise, watershed-scale control of nonnative fishes would alleviate threats from ongoing hybridization (McDonald et al. 2008; Metcalf et al. 2008). Established NFCAs should be large enough to allow long-term persistence of entire communities yet be small enough to be substantively managed in order to address the needs of a full suite of native species with one set of management actions. By focusing on watersheds encompassing Colorado River cutthroat trout, flannelmouth sucker, bluehead sucker, and roundtail chub—in the Upper Colorado River Basin in Wyoming (Upper Green and Yampa subbasins) that have the potential to be managed as NFCAs. We intended to identify NFCAs at the 10-digit hydrologic unit code (HUC) scale (U.S. Geological Survey and U.S. Department of Agriculture [USGS and USDA] 2009) but realized that the exact size would be dependent on specific characteristics of each NFCA. Identification of potential NFCAs is intended to serve as a funding framework for a new National Fish and Wildlife Foundation (NFWF) Keystone Initiative (http://www.nfwf.org) designed to promote conservation of native fishes in the Upper Colorado River Basin under the NFCA concept. Though our goal is to identify one to four watersheds within each major subbasin in the Upper Colorado River Basin (Upper Green, Lower Green, Yampa, Upper Colorado, Gunnison, San Rafael, San Juan, and Dirty Devil-Escalante), we illustrate the identification process and discuss implementation using the Upper Green and Yampa basins in Wyoming as an example.

**Identification of Potential NFCAs**

We identified potential native fish conservation areas through four steps: (1) determine current and potential distributions of Colorado River cutthroat trout, roundtail chub, flannelmouth sucker, and bluehead sucker; (2) conduct a spatial prioritization analysis; (3) identify sympatric and proximate populations within high priority watersheds; and (4) engage experts and management agencies to discuss and—where appropriate—modify analysis results.
Species Data

We used data on the distribution of Colorado River cutthroat trout populations from a range-wide geographic information system (GIS) database assembled during a 2006 status assessment (Figure 1; Hirsch et al. 2006). The database contains the most recent (up to 2005) spatial information on the extent of each conservation population of cutthroat trout—populations that are 90% genetically pure (by genetic testing or professional judgment by biologists) or were otherwise determined to be important for conservation (e.g., unique life history). Populations are represented as stream segments (digital line graphs), and each population is attributed with categorical information on population density, population extent, genetic purity, disease vulnerability, and life history diversity. Each of these five attributes was scored from 1 (bad) to 5 (good) based on Trout Unlimited’s Conservation Success Index (CSI; see Williams et al. 2007 for details). The sum of the five attribute scores (range from 5 to 25) was rescaled to range from 0 to 1.

For our three warmwater target species, we used both known and modeled species occurrences. Known occurrences were based on data from a 2002-2006 Wyoming Game and Fish Department fish survey of the Upper Colorado River Basin in Wyoming (Figure 1; Gelwicks et al. 2009). Stream sites were systematically sampled approximately every 8-16 km on all major streams, and the upstream extent of sampling per stream ceased when the fish community became dominated by salmonids and cottoids. Fish sampling occurred most often in 200-m-long stream reaches isolated with block nets or natural barriers (e.g., beaver dams). One or a combination of gear types was used at each site to maximize sampling efficiency. Most sites were sampled with a shore-based electrofisher or a backpack electrofisher, but cataract and raft electrofishing were used in longer reaches of deeper streams. Seine hauls were made to supplement electrofishing samples. Although the Wyoming Game and Fish Department systematically surveyed streams across the basin, the reaches sampled still represented only a small fraction of total stream length.

To avoid any biases associated with the survey data, and to fill in information gaps, we used spatially explicit predictions of probability of occurrence (sensu Dauwalter and Rahel 2008) for roundtail chub, flannelmouth sucker, and bluehead sucker to estimate likelihood of occurrence in unsampled areas (Figure 2). Spatially explicit predictions were made using artificial neural network models (Olden et al. 2008) developed to model species presence-absence as a function of landscape-scale variables (Dauwalter et al. 2011). Based on the area under the curve (AUC) of a receiver operating plot, the predictive ability of the models was excellent for roundtail chub (AUC = 0.83), outstanding for flannelmouth sucker (AUC = 0.90), and acceptable for bluehead sucker (AUC = 0.71; Hosmer and Lemeshow 2000). Predictions for roundtail chub ranged from 0 to 1 and showed low probabilities of occurrence for many stream segments (mean = 0.05), and a few segments where roundtail chubs occurred—and a few scattered segments in the north—that had high predicted probabilities (Figure 2). Predictions for flannelmouth suckers ranged from 0.01 to 0.84 (mean = 0.10) and showed them most likely to occur along the larger, low-gradient stream systems. Predictions for bluehead sucker were never greater than 0.20 (range: 0.001-0.20) and indicated a low probability of occurrence throughout the basin in Wyoming (mean = 0.04). Probabilities of occurrence were set equal to 1 within the sample reaches where species were known to occur based on the survey data and also on extensively studied streams within the basin where each species is known to occur: Upper Muddy Creek (Compton 2007; Compton et al. 2008), Big Sandy River (Sweet 2007), and Little Sandy Creek (Banks 2009).

Figure 1. Distributions of Colorado River cutthroat trout, flannelmouth sucker, bluehead sucker, and roundtail chub in the Colorado River Basin in Wyoming. Conservation populations of cutthroat trout are from the most recent status assessment (Hirsch et al. 2006), and the integrity of populations was scaled from 0 (low integrity) to 1 (high integrity) based on Trout Unlimited’s Conservation Success Index (Williams et al. 2007). Flannelmouth sucker, bluehead sucker, and roundtail chub distributions are from a 2002-2006 systematic survey by the Wyoming Game and Fish Department; black dots represent sites sampled where flannelmouth sucker, bluehead sucker, and roundtail chub were not detected.
Zonation Analysis

We used the conservation planning software Zonation 2.0 (Moilanen 2008) to prioritize watersheds in the basin in Wyoming to help inform stakeholder discussions (see Stakeholder Discussions below). Zonation uses prioritization algorithms to prioritize landscapes for biodiversity conservation (Moilanen et al. 2005). Within the Zonation analysis we used stream networks attributed with known or potential occurrences of our four target species and information on the costs and risks to conservation to prioritize watersheds. Zonation can implement several landscape removal rules to prioritize watersheds for biodiversity conservation. We used the additive benefit function that iteratively removes landscape units, in our case 12-digit HUC subwatersheds, with the lowest conservation value based on known occurrences or modeled potential occurrences of the target species (Moilanen 2007). We also incorporated upstream-downstream connectivity among subwatersheds, a function that aggregates subwatersheds by explicitly incorporating the connectivity of stream networks (Moilanen et al. 2008). This allows for explicit accounting of the value of tributary watersheds to downstream watersheds when determining their conservation value. We also incorporated information on the costs and risks to focusing conservation in each subwatershed. The costs and risks were based on Trout Unlimited’s CSI, which is a broad-scale assessment tool developed for aquatic resource management (Williams et al. 2007).

The CSI summarizes information on current habitat conditions based on land stewardship, watershed connectivity, watershed conditions, water quality, and flow regime at the subwatershed (12-digit HUC) scale (Figure 3A). The CSI also incorporates information on the future security of subwatersheds based on the risks of land conversion, energy development, resource extraction, climate change, and introduced species (Figure 3A). Each of the 10 indicators (5 each for habitat integrity and future security) were scored from 1 (worst condition) to 5 (best condition), weighted based on the perceived relative importance of each indicator by stakeholders during planning meetings (Figure 3B), and then summed. Though higher scores typically indicate high habitat integrity and future security, we inverted the scores so that higher scores indicated higher costs and risks to conservation. The summed index scores ranged from 0 to 50, with a score of 50 indicating that current habitat conditions and the future security of populations and habitats is poor—meaning that the costs and risks for conservation will be high (Figure 3C). These surrogate costs are explicitly incorporated into the additive benefit function along with known or predicted species distributions when determining the value of watersheds in Zonation (Moilanen 2007). We conducted our Zonation analysis at the 12-digit HUC scale but summarized results at the 10-digit HUC scale to meet our objectives. The end result of the Zonation analysis is a nested hierarchy of conservation priorities, defined as watersheds, across the landscape. The top-ranking watersheds are those that contain the highest number of occurrences, or potential occurrences, of the target species while simultaneously considering costs and river connectivity.

We then identified tier I, II, and III watersheds in each subbasin in Wyoming (Upper Green and Yampa) but only within the top 25% of watersheds ranked by Zonation. Tiers are based on proximity of coldwater and warmwater fishes and are based on the assumption that currently sympatric or proximate populations of native species present greater fish community-based conservation potential. Tier I watersheds were defined as those where

Figure 2. Probability of occurrence predictions from artificial neural network models developed for bluehead sucker (A), flannelmouth sucker (B), and roundtail chub (C) in the Colorado River Basin in Wyoming (from Dauwalter et al. 2011). Predictions were made as a function of variables representing natural landscape features, land uses, and relative abundances of nonnative and hybrid suckers. Probabilities of occurrence were set equal to one in stream reaches were the species are known to occur due to extensive sampling.
Colorado River cutthroat trout and at least one of the three warmwater species—flannelmouth sucker, bluehead sucker, and roundtail chub—are known to occur within the same subwatershed (12-digit HUC). Tier II watersheds were those where Colorado River cutthroat trout and at least one of the three warmwater species occur within the same watershed (10-digit HUC). Tier III watersheds were those that had only cutthroat trout or warmwater species occurring in a watershed (10-digit HUC). Watersheds within each tier were ranked based on the Zonation analysis results.

Very few tier I or II watersheds existed within the top 25% of watersheds ranked by Zonation, indicating that even in the top-ranked watersheds there were few subwatersheds or watersheds with both Colorado River cutthroat trout and one of the three warmwater species. The top 25% of watersheds ranked by Zonation in the Upper Green River Basin represented the entire Blacks Fork Basin due to strong trout populations in the headwaters and occurrences of warmwater fishes in the mainstem, as well as other select watersheds across the study area (Figure 4A). Within the top ranked watersheds, only one tier I and four tier II watersheds existed (Figure 4B). The only tier I watershed, Upper Muddy Creek in the Yampa subbasin, contained sympatric populations of all four species. All four tier II watersheds occurred in the Upper Green subbasin and had different combinations of cutthroat trout and one or two warmwater species in the same watershed (Figure 4B). Remaining highly ranked watersheds represented tier III watersheds (cutthroat trout or warmwater species only) or were tributary to other highly ranked watersheds in the Blacks Fork drainage.

Stakeholder Discussions

The Zonation analysis was based on geographically extensive data sets of species known and potential distributions and landscape-scale variables and therefore cannot capture the details and idiosyncrasies of undertaking conservation in every watershed. Hence, we conferred with agency experts to verify, and modify where appropriate within each tier, watershed rankings of the top 25% of watersheds identified from the Zonation analysis to determine those that could potentially be managed as NFCAs. Stakeholders present were the Wyoming Game and Fish Department, Bureau of Land Management, Forest Service, Trout Unlimited, and The Nature Conservancy. Analysis results were presented to inform the group, and watershed ranks (top 25% identified by the Zonation analysis) were modified within each tier based on discussions of which watersheds could serve best as NFCAs focusing on Colorado River cutthroat trout, roundtail chub, flannelmouth sucker, and bluehead sucker.

Stakeholders generally confirmed the Zonation results in that the top 25% of ranked watersheds represented the best opportunities for cutthroat trout, flannelmouth sucker, bluehead sucker, and roundtail chub conservation under the NFCA concept. They also confirmed the tier I watershed, Upper Muddy Creek (Yampa subbasin). However, on-the-ground familiarity of threats and opportunities in tier II and tier III watersheds indicated the need to rerank some of these watersheds. Though the stakeholders agreed that the top-ranked tier II watershed, Muddy Creek (Blacks Fork), could potentially be managed for native fishes, they thought that land and water uses in the second- and third-ranked watersheds (Upper Blacks Fork and Smiths Fork) would prohibit them from being managed for native fishes. They also thought that the Henrys Fork, the fourth-ranked tier II watershed, represented the best opportunity for native fish management. Hence, the tier II watershed ranks were adjusted due to feasibility of managing them for native fishes and likelihood of conservation success (Table 1), and only the top two stakeholder ranked tier II watersheds appeared to represent potential NFCAs (Figure 5). Likewise, stakeholders thought that tier III watersheds with warmwater fishes should be ranked higher than those with cutthroat trout,
only due to their at-risk status. Tier III watershed rankings were adjusted based on warmwater species presence and abundance (not accounted for explicitly in the Zonation analysis), and the top two stakeholder-ranked tier III watersheds were included as potential NFCAs to reach a total of four watersheds in the Upper Green subbasin (Figure 5). Because only a small fraction of the Yampa subbasin exists in Wyoming (20%), only the top-ranked tier I Upper Muddy Creek was included in the Yampa subbasin in Wyoming (Figure 5). Any remaining potential NFCAs in the Yampa subbasin will be identified as part of an ongoing analysis for Colorado.

**Discussion**

The continued decline of fishes native to the Colorado River Basin suggests that additional management approaches are needed. Using the native fish conservation area approach outlined by Williams et al. (2011, this issue), we combined a quantitative conservation planning approach with stakeholder experience to identify a set of watersheds in the Basin in Wyoming that can serve as potential NFCAs. We describe how watersheds managed under the NFCA concept can help conserve fishes imperiled in the Upper Colorado River Basin, where similar work is already being done, and how the National Fish and Wildlife Foundation Keystone Initiative can help provide a funding mechanism to initiate management in watersheds not currently receiving management attention. Subsequent analyses, similar to the one described here for Wyoming, have been completed in Utah and are ongoing in Colorado to identify additional watersheds that can potentially serve as NFCAs in the remaining portion of the Upper Colorado River Basin.

The prioritization analysis highlighted areas in Wyoming that have potential as NFCAs. It represented a structured and efficient way to prioritize the basin based on species’ known occurrences, potential occurrences, watershed boundaries, and river network connectivity (Sarkar et al. 2006; Nel et al. 2009). The analysis identified a reduced set of watersheds (top 25% of our study area) that then informed discussions with stakeholders about watersheds that could potentially serve as NFCAs. Wenger et al. (2009) used the additive benefit function in Zonation to prioritize the Conasauga River basin in the Southeastern United States for protection and restoration based on occurrences of mussels and fishes. They suggested that quantitative prioritization analyses provide an objective and transparent rationale for conservation programs. Though the additive benefit function in Zonation provided an objective ranking of watersheds in Wyoming based on maximizing the representation of our target species and informed stakeholder discussions, the results required subsequent analysis to get to our tiered endpoint, and discussions with stakeholders highlighted logistical constraints to NFCA implementation and opportunities available not evident from the Zonation analysis. For example, we did not explicitly account for population abundance in the analysis because abundance data were not available for all four species across the entire basin; however, abundance of native suckers was important in stakeholder rankings of tier III watersheds. Though prioritization algorithms and tools are known not to fit perfectly with every application (Ferrier and Wintle 2009; Wenger et al. 2009), we agree that it provided a very useful step in identifying potential NFCAs and informing

---

**Figure 4. Watershed prioritization ranks for the Upper Colorado River Basin in Wyoming (A) and tiers (I, II, and III) of potential NFCAs within the top-ranked (top 25%) watersheds (B). Tier I watersheds have cutthroat trout and at least one warmwater species (flannelmouth sucker, bluehead sucker, and roundtail chub) in the same subwatershed (12-digit HUC), tier II watersheds have cutthroat trout and at least one warmwater species in the same watershed (10-digit HUC), and tier III watersheds have only cutthroat trout or one or more warmwater species in the watershed (10-digit HUC).**
stakeholder discussions within a spatial framework facilitated by readily available GIS coverages and modeling techniques (Groves et al. 2002; Fisher 2004).

Williams et al. (2011, this issue) suggested that NFCAs be able to maintain processes that create diverse habitats, nurture all life history stages, and have sustainable long-term management. Ideally, our study area would have had intact watersheds with both Colorado River cutthroat trout and native warmwater fishes, but no tier I or II watersheds were undisturbed or fully protected (e.g., designated wilderness). However, long-term restoration management, such as in Muddy Creek (see Discussion below), can help the watersheds we identified function naturally, and future land management could result in additional protective measures. The watersheds we identified are all likely to be large enough to nurture all life histories stages of cutthroat trout and three warmwater species. Recent research suggests that Upper Muddy Creek (Little Snake River), Big Sandy Creek, and Little Sandy Creek can have self-sustaining native fish populations with strategic restoration and non-native species management (Hilderbrand and Kershner 2000; Sweet 2007; Compton et al. 2008; Banks 2009). Muddy Creek (Blacks Fork) is the smallest of our identified watersheds, but the management boundary need not explicitly follow the 10-digit HUC boundaries and could be extended downstream if additional research suggests that a key habitat is missing. And, as we outline below, stakeholders are already engaged in long-term management in some watersheds, and funding through the NFWF Keystone Initiative can help initiate long-term management in watersheds not currently receiving attention.

Though our analysis highlighted Upper Muddy Creek (Little Snake River) as a priority watershed, it has already been the focus of native fish conservation by the Wyoming Game and Fish Department, Bureau of Land Management, and other stakeholders for some time and suggests that our analysis aligns with the native fish values that were identified previously. In 2001, Colorado River cutthroat trout were restored to Littlefield Creek, a tributary to Muddy Creek, above a temporary rock gabion fish barrier after nonnative brook trout (Salvelinus fontinalis) were removed with piscicides (Figure 6). Similar cutthroat trout restoration has been expanded to the Muddy Creek headwaters to result in larger extents of occupied habitat, therefore increasing the species’ long-term persistence. Research in Muddy Creek has also led to a better understanding of habitat needs of flannelmouth sucker, bluehead sucker, and roundtail chub (Bower et al. 2008), hybridization with nonnative suckers (McDonald et al. 2008), and how instream structures inhibit fish passage and threaten population persistence (Compton et al. 2008). In 2009, the Rawlins Field Office of the Bureau of Land Management (BLM) proposed Upper Muddy Creek as an Area of Critical Environmental Concern (ACEC) in an attempt to help protect its unique native fish community. The ACEC designation was not adopted by the agency, but a Wildlife Habitat Management Area option was and will afford some protections when compared to other BLM land designations. Mechanical removal of nonnative fishes is ongoing, as is monitoring to evaluate trends of both native and nonnative populations. Future work will include strategic barrier management that reconnects native fish populations in some areas and isolates them from nonnatives in others, chemical removal of nonnative fishes in the lower watershed, channel restoration, livestock management, and community outreach.

### TABLE 1. Top-ranked watersheds (10-digit HUC) within each tier from Zonation analysis and revised rankings based on stakeholder discussion. Tier I watersheds have cutthroat trout and at least one warmwater species (flannelmouth sucker, bluehead sucker, and roundtail chub) in the same subwatershed (12-digit HUC), tier II watersheds have cutthroat trout and at least one warmwater species in the same watershed (10-digit HUC), and tier III watersheds have only cutthroat trout or one or more warmwater species in the watershed (10-digit HUC)

<table>
<thead>
<tr>
<th>Subbasin</th>
<th>Zonation Rank</th>
<th>Stakeholder Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yampa</strong> (WY only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1. Upper Muddy Creek (Little Snake River)</td>
<td>1. Upper Muddy Creek (Little Snake River)</td>
</tr>
<tr>
<td>II</td>
<td>None in top 25%</td>
<td>NA</td>
</tr>
<tr>
<td>III</td>
<td>None in top 25%</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Upper Green</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>None in top 25%</td>
<td></td>
</tr>
</tbody>
</table>
| II             | 1. Muddy Creek (Blacks Fork)  
2. Upper Blacks Fork  
3. Smiths Fork  
4. Henrys Fork | 1. Henrys Fork  
2. Muddy Creek (Blacks Fork)  
3. Upper Blacks Fork*  
4. Smiths Fork* |
| III            | 1. Little Muddy Creek  
2. Cottonwood Creek (Blacks Fork)  
3. Middle-Lower Blacks Fork  
4. Hams Fork  
5. La Barge Creek  
6. Big Sandy River  
7. Little Sandy Creek | 1. Big Sandy River*  
2. Little Sandy Creek*  
3. Middle-Lower Blacks Fork  
4. Bitter Creek*  
5. Hams Fork  
6. La Barge Creek  
7. Cottonwood Creek (Blacks Fork)  
8. Little Muddy Creek |

*Stakeholders thought that land and water uses in these watersheds reduced the likelihood of large-scale native fish management and the watersheds were reduced in rank.  
*Only the top two stakeholder-ranked tier III watersheds were included in the final set of potential NFCAs in the Upper Green subbasin.  
*Not within top 25% of Zonation rankings but included after stakeholder discussions because it is the only watershed in Wyoming where the flannelmouth sucker has not hybridized with the nonnative white sucker.
holders and ongoing financial support. Though Upper Muddy Creek has been managed like an NFCA over the past decade, and Big Sandy River and Little Sandy Creek have received significant attention since 2002, additional resources and stakeholder support for native fish conservation in other watersheds, like the Henrys Fork and Muddy Creek (Blacks Fork), will be necessary to achieve long-term conservation goals. This will be difficult given current agency commitments, limited budgets, and conservation priorities in watersheds that do not meet the goals of our analysis for the NFWF Keystone Initiative (i.e., proximate populations of cutthroat trout and warmwater species). For example, the Wyoming Game and Fish Department, in addition to Upper Muddy Creek, Big Sandy River, and Little Sandy Creek, is currently focused on conservation of the flannelmouth sucker in Upper Bitter Creek. Upper Bitter Creek is the only watershed in Wyoming where flannelmouth sucker are not hybridizing with nonnative suckers (Gelwicks et al. 2009). Consequently, Upper Bitter Creek is an agency priority because it contains a genetically pure flannelmouth sucker population important to future conservation efforts. So although it does not represent an ideal NFCA that benefits multiple native species, it is a valid and high priority watershed for native fish management. And though Wyoming Game and Fish Department does recognize Muddy Creek (Blacks Fork) and Henrys Fork as important for native fish conservation, they have given priority to Upper Muddy Creek, Big Sandy River, Little Sandy Creek, and Upper Bitter Creek to ensure that the more abundant or genetically pure populations in those watersheds are stabilized and protected from current threats before shifting management attention to new watersheds where multiple native fish species may occur in close proximity, but current threats are less imminent (D. Miller, Wyoming Game and Fish Department, personal communication). The contrast between Upper Muddy Creek, where abundant populations of cold and warmwater native species are sympatric, and Upper Bitter Creek, where native species richness is low but the flannelmouth sucker population has high genetic value, illustrates well the complementary nature of NFCAs focused on entire native fish communities.

Long-term funding is also needed to ensure that enough resources are available to implement broad-scale native fish conservation. In the Upper Colorado River, the National Fish and Wildlife Foundation committed approximately $5 million over the next 10 years toward native fish restoration under their new Keystone Initiative based on the NFCA concept. The NFWF funding can represent additional resources for watersheds like Upper Muddy Creek, Big Sandy River, and Little Sandy Creek. It can also represent seed money for needed conservation actions in the Henrys Fork, Muddy Creek (Blacks Fork), and other potential NFCAs throughout the Upper Colorado River Basin. For example, NFWF has funded a part-time project manager located in Green River, Wyoming, to help administer NFWF-funded restoration projects in Upper Muddy Creek. Continued funding for project management could help initiate work in watersheds like Muddy Creek (Blacks Fork)
and Henrys Fork, despite other stakeholder resources currently being limited. Eventually, however, other funding sources will be needed to leverage NFWF funding and complete the amount of work necessary for large-scale aquatic conservation throughout the Basin.

Through our stakeholder discussions, we also identified factors that compromise ecological integrity and pose future threats in our NFCAs and throughout the Upper Colorado River Basin. Human use of scarce water resources in the West and Colorado River Basin threaten native fishes (Richter et al. 1998; Deacon et al. 2007). The non-native white sucker now dominates fish assemblages in the Colorado River Basin in Wyoming, and hybridization with native suckers has created genetic bridge between native suckers that were previously reproductively isolated (McDonald et al. 2008; Gelwicks et al. 2009). Fish passage barriers fragment watersheds and fish populations throughout the basin (Hilderbrand and Kershner 2000; Compton et al. 2008). Habitat alteration due to grazing and other land uses is still prevalent (Armour et al. 1991). Though NFCAs can allow for compatible commercial and recreational uses, uses such as grazing or energy development should not adversely impact native fish communities and aquatic ecosystems. If they have negative impacts, proper mitigation should be ensured (Groves 2003; Kiesecker et al. 2010).

Proactive NFCA-type management can also help protect native fishes from several impending future threats (Clarkson and Marsh 2010). Introduced species, such as burbot, continue to invade new habitats and threaten native fishes (Olden et al. 2006; Sweet 2007). Oil and gas activity has increased substantially in the Intermountain West, and much of Wyoming has a high risk of being developed in the future (Copeland et al. 2009). The impact of development to native fishes is not completely clear (Davis et al. 2009; Farag et al. 2010), but bluehead suckers have been shown to be negatively associated with development (Dauwalter et al. 2011). Trout are threatened by increased temperatures and uncharacteristic wildfires under a warming climate (Williams et al. 2009), disturbances that have caused small, isolated populations to go extinct (Brown et al. 2001). Synergies between these threats could be particularly problematic, because climate change is expected to create new invasion pathways for invasive species (Rahel and Olden 2008). Proactive management under the NFCA concept can alleviate such threats by focusing on nonnative species control, facilitating interconnected fish communities with intact metapopulation dynamics and increased likelihood of persistence, focusing on restoration activities that buffer against climate change impacts, and limiting oil and gas development in key areas.

Native fishes across North America are in decline, and the native fish conservation area concept represents a proactive management approach to native fish conservation that focuses efforts on entire fish communities rather than waiting until individual species require recovery actions. Though similar watershed-scale approaches have been proposed, most have lagged behind marine protected areas (Shipley 2004), and most successful freshwater applications have occurred on isolated springs and lakes (Suski and Cooke 2007). However, the NFCA concept in the Upper Colorado River Basin is gaining inertia and has the potential to complement existing management approaches and benefit entire communities comprised of highly endemic and declining fish species.

ACKNOWLEDGMENTS

We thank everyone who participated in stakeholder discussions across multiple agencies and organizations. We also thank D. Miller, K. Fesenmyer, and anonymous reviewers for critical comments that improved the manuscript. The project was funded by National Fish and Wildlife Foundation agreement 2009-0076-000 and Trout Unlimited’s Coldwater Conservation Fund.

REFERENCES


Banks, D. T. 2009. Abundance, habitat use, and movements of blue-


American Fisheries Past President, Don Jackson, Becomes the Deputy Director of the Northern Gulf Institute

Two distinguished research professors from Mississippi State University (MSU) have joined the leadership at the Northern Gulf Institute (NGI) according to Dr. David R. Shaw, MSU Vice President for Research and Economic Development. Robert J. Moorhead; Billie J. Ball, Distinguished Professor of Electrical and Computing Engineering; and Donald C. Jackson, American Fisheries Society Past President and Sharp Distinguished Professor of Fisheries, have recently been selected to serve as NGI director and deputy director, respectively. Dr. Moorhead is also director of the Geosystems Research Institute, the founding entity for NGI.

Dr. Moorhead has an extensive background in scientific visualization research, having served as director of the Visualization, Analysis, and Imaging Laboratory and deputy director of the Computational GeoSpatial Technologies Center. He was the deputy director of the Geosystems Research Institute (GRI) at MSU prior to taking the lead at both GRI and NGI. His current research interests include computationally demanding visualization and analysis issues. He has almost a 100 journal and peer-reviewed publications.

Dr. Moorhead received his B.S.E.E. degree from Geneva College, Beaver Falls, Pennsylvania, and his Ph.D. degree in electrical and computer engineering from North Carolina State University. Prior to his employment at MSU, he was a research staff member at the IBM T. J. Watson Research Center. He served 6 years as summer faculty at the Naval Oceanographic Office, Stennis Space Center, and was the Scientific Visualization Research Thrust Leader in the MSU National Science Foundation Engineering Research Center for Computational Field Simulation. He has worked extensively with both the National Aeronautics and Space Administration and the Naval Research Lab at Stennis Space Center in various research projects over the last 15 years.

Dr. Jackson comes to NGI from the Department of Wildlife, Fisheries and Aquaculture at MSU, most recently focusing in river and coastal zone fisheries research, management, and development—with his most recently published work more specifically in fisheries ecology and management following hurricanes. Dr. Jackson recently served as President of the American Fisheries Society. He has also served as President of the Mississippi Wildlife Federation. He is a past recipient of the Mississippi Wildlife Federation’s Fisheries Conservationist of the Year Award and the American Fisheries Society Fisheries Management Section’s Award of Excellence and was elected a Fellow in the American Institute of Fisheries Research Biologists.

Dr. Jackson received his B.S. degree in zoology and his M.S. degree in zoology/limnology from the University of Arkansas and his Ph.D. in fisheries management from Auburn University. He has worked on international fisheries assignments in Southeast Asia, Africa, and Latin America.

Fisheries Top Ten—Fun Facts from the 2010 SOFIA Report¹
by Jesse Trushenski

1. Together, fisheries and aquaculture provided the world with ~142 million metric tons of fish every year.
2. Worldwide, seafood provides more than 1.5 billion people with almost 20% of their average per capita intake of animal protein.
4. Though global aquaculture production was less than 1 million metric tons in the 1950s, culturists now produce over 50 million metric tons per year, at a value of nearly US$100 billion.
5. The fish industries support the livelihoods of a total of about 540 million people, or 8% of the global population.
6. The global fishing fleet is made up of about 4.3 million vessels, working to harvest the world’s oceans and inland waterways.
7. The number of stocks identified as overexploited, depleted, or recovering from depletion in 2008 is the highest recorded to date.
8. China, Norway, and Thailand are the top three fish exporters.
9. Seafood consumers, particularly in the more prosperous regions, are increasingly demanding that seafood be guaranteed as sustainably harvested or raised.
10. By volume, anchoveta are the number one global marine fishery, with landings weighing in at more than 7 million metric tons per year.

¹ These figures were taken from the 2010 Food and Agriculture Organization’s State of World Fisheries and Aquaculture Report, available at: http://www.fao.org/docrep/013/i1820e/i1820c00.htm.
International Fisheries Section

Join our FACEBOOK page! Search "International Fisheries Section, AFS" or click this link http://www.facebook.com/#!/ group.php?gid=101314800383 and click "Join." We will use the Facebook page for announcements related specifically to international fisheries and the International Fisheries Section and encourage discussion through this forum.

The 141st Annual Meeting of the American Fisheries Society will occur 4–8 September 2011 in Seattle, Washington. The International Fisheries Section has been involved with the meeting’s planning committee to help ensure that this year’s meeting has the largest international audience yet. Please contact anyone within the International Fisheries Section if you’d like any information about traveling to this meeting.

An American Veterinary Medical Association Certificate of Appreciation presented to Rosalie (Roz) Schnick in grateful recognition for the exemplary efforts as the National Coordinator for Aquaculture New Animal Drug Applications (1995–2010) in working with the American Veterinary Medical Association and its members, federal agencies, aquaculture industries, and the pharmaceutical industries in expanding the availability of therapeutic agents for aquaculture.

Virginia Chapter

Reported by William B. Kittrell, Jr.
Former Secretary, Virginia Chapter, AFS

The 21st annual meeting of the Virginia chapter American Fisheries Society (AFS) was held at Cacapon State Park near Berkeley Springs, West Virginia, February 8–10, 2011. The meeting was held in conjunction with the West Virginia chapter’s annual meeting. Eighty-four fisheries and aquatic resource professionals attended the joint meeting. An additional 18 students, from numerous universities across the region, also participated. Two continuing education workshops were offered at minimal cost on February 8. The first workshop, “Field Chemistry Refresher,” was taught by Dr. Dan Downey of James Madison University. Zac Loughman, an instructor at West Liberty University, conducted the second workshop entitled “Natural History, Conservation and Taxonomy of West Virginia and Virginia Crayfish.” Meeting participants enjoyed an all-you-can-eat buffet dinner and social hosted by the Virginia and West Virginia chapters on Tuesday evening.

The technical presentations began on Wednesday morning with concurrent sessions featuring topics on warmwater gamefish as well as aquatic communities. The afternoon concurrent sessions focused on trout and fish health, respectively. Another all-you-can-eat buffet and social was hosted by the Virginia and West Virginia chapters on Wednesday night. During the social, the Virginia chapter AFS hosted a raffle emceed by Bob Andrews, Bill Kittrell, and Cory Kovacs. It was a huge success, with approximately $800 generated for student scholarships and other worthy endeavors. The Thursday morning technical session included topics pertaining to trout and habitat restoration. When the meeting concluded Thursday at noon, 33 technical presentations had been given, with an additional 11 posters presented during the Wednesday evening social.

The annual business meeting was held in the afternoon on Wednesday, February 9, with President Elect Bob Andrews presiding. The chapter president, Adrienne Averett, had accepted a position in Oregon the previous year and could not attend the meeting. Pat Mazik gave a brief status report on the Southern Division AFS. The Robert Ross Graduate Scholarship was awarded to Ryan Schloesser of VIMS. The Robert Jenkins Undergraduate Scholarship was awarded to Jason Emmel of Virginia Tech. Both scholarships were awarded at the full $500 level. Only one award for the best student paper was given this year, and it went to Shannon White of Virginia Tech. The Natural Resource Conservationist award was given...
to Ryan Hodges of Warm Springs in Bath County. John Kauffman was presented a Lifetime Distinguished Service Award for his career achievements and dedication to fisheries science. Bob Andrews was installed as president, and Adrienne Averett will now serve as past president. Vic DiCenzo and Cory Kovacs were installed as the new president elect and secretary, respectively. Morgan McHugh will continue to serve as chapter treasurer, and Robert Humston continues as newsletter editor.
**Wisconsin Chapter**

The Wisconsin chapter American Fisheries Society (AFS) held its 40th annual meeting in Stevens Point from January 31 to February 2, 2011. A blizzard dropped up to 2 feet of snow in southern Wisconsin during the meeting, but 223 were still able to attend. The meeting theme, “Through the Looking Glass,” focused on how fisheries and fisheries management have evolved in Wisconsin. “Well-seasoned” professionals who were there at the formation of the chapter were invited to speak on how fisheries and AFS have changed since the 1960s. John Magnuson (WI-AFS president, 1974; parent society president, 1981–1982) talked about the formative years of Wisconsin AFS. Ron Poff (WI-AFS president, 1977) spoke on fish propagation. A historic view of warmwater fisheries management was presented by Gordon “Gordie” Priegel (WI-AFS secretary-treasurer, 1974–1975). Lyle Christianson played a key role in the formation of the chapter, and he offered his recollections in a letter. Lee Kernen gave his perspective as a Lake Michigan fisheries manager when salmon were first introduced to the lake and northern pike and walleye began to rebound on Green Bay. Another 22 talks and 11 posters rounded out the meeting, with the Steve Yeo best student paper awarded to Matthew Faust of University of Wisconsin–Stevens Point and Dr. Michael Hansen, advisor, for “Age and Growth of Muskellunge in Wisconsin’s Ceded Territory.” The Steve Serns best professional paper went to Ron Bruch, for “Recovery of the Lake Sturgeon Population in the Winnebago System, 1970–2010.” Elliot Hoffman and coauthor Al Niebur received an award for best poster, “Comparison of Otolith and Scale Methods for Ageing Bluegill and Black Crappie.” Six additional presentations were given after hours at a special “Barroom Biology” forum, with top honors awarded to Pete Segerson for his plans if appointed Wisconsin Deer Czar, Steve Gilbert’s formula to calculate his odds of going fishing, and John Kubisiak’s explanation of how timber wolves have negatively impacted walleye populations.

**New York Chapter**

The New York chapter held its annual continuing education program and business meeting at the Inn on the Lake in Canandaigua, New York, on 2–4 February 2011 with the theme of Aquatic Habitat Restoration. During the plenary session, chapter members heard from five invited speakers and six other speakers, including two students. The program also had 15 contributed papers (including six student presenters) and 17 posters, including five from students. A concurrent workshop on submersed aquatic vegetation identification and aquatic vegetation ecology and management was offered as the continuing education program of the meeting. Despite severe winter storm warnings throughout the Midwest and Northeast, 126 attendees were registered, including 29 students from four colleges. Sixty-five meeting attendees participated in the workshop. Attendees came from the Department of Environmental Conservation, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, U.S. Army Corps of Engineers, several universities, county governments, and private industries.

The New York chapter was able to offer the 2011 annual continuing education program and business meeting to its...
Membership at the same rate as the 2010 meeting. Travel awards were given to six students as a result of an application process. It allowed these students to attend the 2011 meeting at very little cost to them. Registration was also waived for three students giving oral presentations. The chapter gives out up to four awards at its annual meeting: the Professional Achievement Award, the Conservationist of the Year Award, Honorary Member Award, and the David Bryson Memorial Award. Student Best Paper, Poster, and Travel Awards are also given out. Tyler Ross was awarded the best student oral presentation, and Emily Cornwell was awarded the best student poster. At the banquet, H. George Ketola received the Professional Achievement award, the Seth Green Chapter of Trout Unlimited received the Conservationist of the Year Award, and James McKenna, Jr., was awarded a David Bryson Memorial Scholarship award.

Ed Woltmann was installed as New York chapter president for 2011–2012, and the membership elected Frank Flack as president elect. During the business meeting, Ed announced his plans for several chapter events in 2011. The New York chapter provides for an electronic newsletter to its membership, and the chapter website will be redesigned later this year.

The New York chapter oversees the AFS student subunits at Morrisville State College, Cornell University, SUNY Fredonia, and SUNY Cobleskill. The Cornell University student subunit with support from the chapter plans to organize a New York State student colloquium in 2011.

**Unit Awards**

**Dakota Chapter**

Past President – Mike Barnes
Aquatic Resource Conservation Award – Chris Nannenga & Ransom County Soil Conservation District
Robert L. Hanten Distinguished Professional Service Award – Brian Blackwell
Outstanding Young Professional Award – Matt Ward
Outstanding Young Professional Award – Jerry Wilhite,
Best Student Paper – Luke Schultz
Best Professional Paper – Paul Bailey
Best Poster – Matthew Ward

**North Carolina Chapter**

Meeting, Charlotte, North Carolina; February 23, 2011
Best Professional Paper – Tyler R. Black
Best Student Paper – Justin Dycus

**Montana Chapter**

Meeting: Great Falls, MT, February 10, 2011
Best student presentation – Matthew Corsi
Best professional presentation – Matthew Boyer

**Early Life History Section**

Meeting: Wilmington, North Carolina, May 25, 2011
Past president – Jonathan Hare
Elbert H. Ahlstrom Career Achievement Award – Edward Houde

**Michigan Chapter**

Meeting: Petoskey, Michigan, April 7, 2011
Past president: – Mark Tonello
Lotek multi-mode acoustic transmitters make it possible to correlate coastal movement with fine scale interactions.

Low power, low cost analog acoustic receivers make up the existing coastal arrays where minimization of deployment/recovery costs is the priority. These sites are also characterized by low noise and very small numbers of relatively slow moving fish.

High power digital acoustic receivers make up the fine scale arrays where system resolution is the priority. These sites are characterized by high noise and large numbers of fish congregating, interacting with habitat (e.g. spawning), other species (e.g. predation) or being subject to anthropogenic effects (e.g. construction, sonar, boat traffic, etc.).

Fish tagged with Lotek multi-mode acoustic transmitters are detected by both the existing coastal arrays (migration pattern) and the fine scale arrays. Fine scale interactions and anthropogenic influences can be directly linked to changes in migration behavior.

Now available with temperature, pressure and motion sensors. For more information, please visit www.lotek.com/mm.
As bass boats and crappie rigs fly down county roads headed for the morning bite at large reservoirs in Mississippi and Arkansas, many of their owners don’t realize that they are most likely driving past some of the best waters in the region without so much as a second glance. I’m not talking about the “Mighty Mississippi” or trout-filled streams that weave beneath roadways in the Arkansas Ozarks; I’m talking about oxbow lakes.

Oxbow lakes are former river bends that have been cut off from the river by natural or human-induced processes. Most oxbow lakes in Mississippi and Arkansas are situated within the former floodplain of the lower Mississippi River, technically known as the Mississippi Alluvial Valley but commonly referred to simply as the “Delta.” Many oxbows are far off the beaten path, down overgrown trails and levee roads. Therefore, oxbow lakes are perhaps the most neglected aquatic resource in the region.

Oxbow lakes are unique ecosystems that harbor unique and diverse fish communities. One thing that contributes to the diversity of fishes in oxbow lakes is the wide range of settings in which oxbows are located. Oxbows have a variety of sizes, depths, watershed compositions, and degrees of connectivity to their former river channels. All of these factors can interact to influence what species are present and how abundant they are. Even though the fish communities may be unique and diverse, previous studies have shown that the ecological well-being of many oxbow lakes is impaired.

Ecological well-being can be judged in a variety of ways, but one of the easiest and most convenient methods is an assessment of the fish species richness. Species richness is simply a count of how many species are present in the lake. In general, a greater number of species equals a healthier system. Maintenance or enhancement of fish species richness may be the key to improving the well-being of oxbow lakes. Unfortunately, factors that influence fish species richness in oxbow lakes are very obscure.

To improve the ecological well-being of Delta oxbow lakes, research is in progress to determine variables that may influence the fish species richness. Researchers from Mississippi State University are attempting to estimate the effects of fundamental environmental variables on fish species richness. Fundamental environmental variables, namely, depth, surface area, watershed land use, and degree of connectivity to the former river channel, are those variables thought to be the driving forces behind other variables that may influence fish species richness. For example, agricultural fields in the watershed may influence water transparency, which in turn may influence what species are present in the system.

Throughout the summer of 2009, sampling trips were made to oxbow lakes in Mississippi and Arkansas. Lakes were selected to have a diverse representation of fundamental environmental variables. Fish were sampled using electrofishing, a relatively harmless method of fish collection that stuns fish as an electric current is passed through the water. Stunned fish floated to the surface, after which they were quickly netted, identified, and released. At the close of the day, we ended up with a count of the total number of species from each lake.

Once all of the species richness and environmental data had been collected, we began to see relationships between the two. In particular, we looked to see how species richness responded to changes in the environmental variables. If species richness exhibited a large response to a change in an environmental variable, that variable was thought to have a large effect on fish species richness.

Those variables that were considered to be influential over fish species richness could be used as targets for management and restoration efforts. Once plans were enacted to address influential environmental variables, we then began to make changes that would facilitate the preservation and restoration of fish species richness in oxbow lakes. Sampling is set to continue throughout the summer of 2010, so we can continue to learn about what influences fish species richness in these unique ecosystems.
Recently Certified Professionals

The American Fisheries Society’s professional certification program provides a way for fisheries professionals who achieve specific standards of professional competence to be recognized. Congratulations to the following individuals who were recently approved as certified professionals.

### Approved November 5, 2010

**Certified Fisheries Professionals-FPC:**
- Frank J. Rahel
- Trent Sutton
- William Seaman
- Kevin Johnson
- Ronald Wayne Pierce
- Douglas E. Olson
- Douglas Duncan
- Laura Leslie Burckhardt
- Trina Hedrick
- Nathaniel Corey Oakley
- Gregory W. Murphy
- Steve Howard
- Cory Goldsworthy
- Michelle Cain

**Associate Fisheries Professionals-FPA:**
- Brent M. Courchene
- Daphne Kampinga
- Brandon Armstrong
- Jonah Dagel

### Approved February 11, 2011

**FPC:**
- Matt A. Kulp
- Gretchen Anne Sausen
- Carl Ruetz
- Jen Stone
- Beverley Chaney
- Roger C. Viadero
- Umberto Luzzana
- Tami S Clabough
- Frank P Thrower
- Richard Grost
- Cynthia H. Contreras
- William Somer
- Dan Kenney
- Bert Mulchaey
- Jesse Trushenski

**FPA:**
- Jessica Strickland
- Mark Kaemingk
- Aaron J. Von Eschen

### Approved May 9, 2011

**Certified Fisheries Professionals:**
- David Clapp
- Frank Shrier
- Clara J. Weloth
- Steven J. Kerr
- Ronald M. Koth
- Trent Lewis
- Darren Tyler Rhea
- Eric L. Brinkman
- Jason C. Doll
- Bradley A. Ray
- Rick Spear
- Kevin Hining

**Associate Fisheries Professionals:**
- Charles Barnes Jr
- Darren Wood
- Jay Haffner

---

Sonotronics Celebrates 40 years
Offering a Two Fold approach...

**New transmitters available**
Now offering the R-cc transmitter, an R-code companion transmitter.
Compatible with other Vendors’ and Sonotronics SUR receivers.

**Sonotronics**
“working together to make a difference in the world we share”
www.sonotronics.com • (520) 746-3322

[Communication] Replacement of Fish Meal with Ethanol Yeast in the Diets of Sunshine Bass. Brian Gause and Jesse Trushenski. 73: 168–175.


Special Section: Lipids in Aquaculture

Introduction to a Special Section: Lipids in Aquaculture Nutrition and Physiology. Rebecca T. Lochmann and Jesse T. Trushenski. 73: 187.


Growth Performance and Tissue Fatty Acid Composition of Rainbow Trout Reared on Feeds Containing Fish Oil or Equal Blends of Fish Oil and Traditional or Novel Alternative Lipids. Jesse T. Trushenski, Patrick Blaufuss, Bonnie Mulligan, and Jérôme Laporte. 73: 194–203.

Selective Fatty Acid Metabolism, Not the Sequence of Dietary Fish Oil Intake, Prevails in Fillet Fatty Acid Profile Change in Sunshine Bass. Jesse T. Trushenski, Brian Gause, and Heidi A. Lewis. 73: 204–211.

Differential Incorporation of Dietary Fatty Acids from Flax and Fish Oils into Lipid Classes of White Bass Ova. Heidi A. Lewis, Jesse T. Trushenski, Ryan L. Lane, and Christopher C. Kohler. 73: 212–220.


New AFS Members

Leslie Ager
Anke Anke
Chris Baker
Rebecca Barnett
Marc Beccio
Natalie Beckman
Gregorio Benavides
Pryia Bhavan
Heidi Block
Timothy Blubaugh
Nereida Bravo
Kyle Broadway
Andrew Bruce
Matthew Butler
Robert Caballero
Bryan Cage
John Caldwell
Beverly Catlett
Mark Chilcote
Sarah Chronister
Warren Currie
Courtney DePass
Kris Dey
Brian Diunizio
Mark DuFour
Ryan Easton
Michael Edmondson
Samantha Ehner
Allan Eldridge
Jens Eligehausen
Valerie Evans
Paige Face
Sierra Franks
Lincoln Gagnon
Gordon Gibbs
Michael Goettel
Spike Gouge
Trevor Graddy
Jay Haffner
Michael Hawley
Josh Hesselbein
Gary Hogrefe
Randy Honebrink
Lacey Hopper
John Hutchinson
Lauren Jescovitch
Pamela Jewkes
Donald Kennedy
Greg King
Tamara Knudson
Philippa Kohn
Cory Kovacs
Nick Lacombe
Bradley LeQuieu
Anjunell Lewis
Ron Lewis
Taylor Lowrey
Annakarina Marinos
Kathryn Matthews
Megan McGilvray
George Mears
Sarah Melton
Elena Millard
Justin Morgan
Chris Neidhardt
Jonathon Newkirk
Katherine Nordholm
Oluseyi Okuneye
Ciar O’Toole
Keith Parker
Douglas Parkinson
Anitra Pawley
Jesse Peach
Stephen Perry
Stephen Pescitelli
Jim Pipas
Anna Priester
Stephen Pyecroft
Robert Ramey
Amy Robinson
Konstantine Rountos
Steve Ruda
Nick Sanders
Virginia Sanders
Roar Sandodden
Melissa Scheperle
Kayla Severino
Rebecca Seyferth
Stanley Smith
Michael Sprague
John Sproul
Imam Syuhada
Sarah Teck
Nathanial Tessler
Stephanie Theis
Samuel Urmy
Thea Vanderwey
Paul Wagner
Jonathan Williams
Emily Williams
Heather Wolfer
Caselle L. Wood
Jennifer Woodroffe
Daniel Worth
Shaowen Ye
From the Archives

Report of the Meeting of Organization. New York City, December 20, 1870. “A meeting of practical fish culturists was held in this city to-day, in compliance with a call issued November 1st by W. Clift, A.S. Collins, J.H.Slack, F.Mather and L. Stone. The original place for meeting was subsequently changed to the rooms of the New York Poultry Society, to which society the delegates are much indebted, both for the use of the rooms and for various other courtesies extended to them during the day.”

American Fisheries Society, Transactions 1-9, 1872-80

“For the benefit of those to whom this part of the subject is unfamiliar, I will say that the milt or seminal fluid of the male fish consists [or contains, I have forgotten the exact language in that case] of innumerable living microscopic organisms, called spermatozoa or zoösperms; these millions of infinitesimal creatures, during their brief career in the outer world, are endowed with great activity, and jump and plunge about among one another with a motion as ceaseless as it is rapid and vigorous.”

Livingstone Stone, p. 16, American Fisheries Society, Transactions 1-9, 1872-80

“The great question at issue, and one which demands the earnest attention of every lobster fisherman and dealer, is whether lobsters are decreasing in abundance, and will eventually become rare and difficult to obtain, or whether they are still as plentiful as ever and show no indications of approaching extinction. While we hope for the latter, we are forced to acknowledge that a careful study of all materials at our command inclines us to belief that the abundance of lobsters has very perceptibly diminished within comparatively recent times, and that, unless some active measures are instituted to prevent continued decrease in the future, a great and irreparable injury to the fishery will ensue.”

Richard Rathbun, Transactions of the Thirteenth American Fish-Cultural Association, 1884

In conclusion I would say that persons owning trout ponds could do nothing better than place a few large carp in them. For a time they will become less shy than the trout, and will actually raise their heads out of the water to take a piece of bread out of your fingers. This season I fed my carp with stale bread, refuse of the table, potatoe peels, etc., and I find that they do not refuse soft or damaged apples. In fact, they eat almost any vegetable food, properly chopped, and if possible partially cooked. I give you this, gentlemen, in my crude way, and without embellishment in any form, using no long-tailed Latin words or names, but simply trusting in the efficacy of our English tongue to convey to you my meaning.

Hugh M'Govern, Transactions of the Eleventh American Fish Cultural Association, 1882

Materials of Which Fish are Composed. Considered from the standpoint of the food value, fish, as we buy them in the markets, consist of --

1. Flesh or edible portion.
2. Waste -- bones, skins, entrails, etc.

The proportions of waste matter in different kinds of fish and in different samples of the same kind in different conditions vary widely. Thus a sample of flounder contained 68 per cent., of waste matter and only 32 per cent. of flesh, while one of halibut steak had only 18 per cent. of waste and 82 per cent. of edible materials. Among those with the most waste and least edible flesh are the porgy, bass, perch, lobster and oyster. Among those with the least waste are fat shad, fat mackerel and dried and salt fish.

Coming to the edible portion, the flesh, we find this to consist of --


Prof. W.O. Atwater, Transactions of the Tenth American Fish Cultural Association, 1881
Education in the Era of the Millennials and Implications for Future Fisheries Professionals and Conservation

Kelly F. Millenbah, Bjørn H. K. Wolter, and William W. Taylor

Millenbah (E-mail: mille nba@msu. edu) is the Associate Dean of Lyman Briggs College and an Associate Professor in the Department of Fisheries and Wildlife (FW) in the College of Agriculture and Natural Resources at Michigan State University. Wolter is a postdoctoral researcher with the Department of Fisheries and Wildlife at Michigan State University. Taylor is an AFS past president and University Distinguished Professor in Global Fisheries Systems at Michigan State University.

ABSTRACT: Fisheries and other natural resource professionals face growing challenges in their fields and the resources that they manage. Many are well aware of the pending impacts of retirement of the Baby Boomers and the loss of collective knowledge held by those individuals. We are also acutely aware of the damaging impacts of reduced budget allocations for natural resources–based programs. Concomitant to the decrease in funding is the ever-increasing complexity of the fisheries discipline that brings with it new and more complicated ecological and governance challenges. These, and the evolving preferences, morals, and values of today’s college students, pose a unique and difficult dynamic for engaging the next generation in the stewardship of fish and wildlife resources. Critical to the success of future conservation efforts will be the modification of educational and workplace systems, including the American Fisheries Society, to prepare and support future professionals so that they may handle this suite of complex, interdisciplinary issues. Understanding the characteristics of the next generation of natural resource leaders, and the individuals with whom they will interact in pursuit of conservation, is key to ensuring that they can meet the challenges of a new era in resources management. The purpose of this article is to describe the next generation of fisheries professionals (the Millennials) and to provide suggestions for how higher education and the fisheries profession can best prepare to support the success of this generation and ultimately the future of fisheries conservation and management.

Millennials

The current generation of college-aged students, typically born after the mid-1980s, was labeled the “Millennial Generation” by Howe and Strauss (2000). It is second only to the Baby Boomers in size, representing roughly 26% of the American adult population (McGlynn 2005; U.S. Census Bureau, 2005). Almost 34% of Millennials in the United States are black, Hispanic, Asian, or Native American, making them the most culturally diverse generation this nation has ever known. Family demographics are changing too. One-third of Millennial students are arriving at college from single-parent homes (Major 2002), and the number from biracial or stepfamilies and same-sex partnerships are also on the rise (Broido 2004). Though generalizations rarely apply to individuals, they can describe an overall picture of a group. The following are attributes that have been identified by various researchers (e.g., Howe and Strauss 2000; Zemke 2001; Broido 2004; DeBard 2004; McGlynn 2005; Taylor 2005; Mangold 2007) as descriptive of the Millennial Generation.

Special

Millennials are the generation where “everyone is special.” In many ways, they are the product of their Boomer parents’ obsession with the concept of fair play. Their parents grew up in an era where academic worth was predicated solely on performance, and performance was closely linked to socioeconomic, family, and regional factors. However, when the Boomers came of age, they rejected this archetype, instead swinging the pendulum to the opposite end of the spectrum. They have taught their children that they are special regardless of performance, which in and of itself is not necessarily bad; however, they have ruthlessly advocated and pursued this doctrine to the extent that it has bred a generational sense of entitlement in Millennials—that their problems are the nation’s problems, their future is the country’s concern, and because of this they are owed something (e.g., an education, a career, a middle-class lifestyle). McGlynn (2005:14) notes that, “…many of our college students expect individual attention, extra help, and other institutional resources to be provided in order to help them with any difficulties which they encounter.”

Sheltered

Any discussion of higher education in the 21st century must include parents. Universities and colleges across the nation are seeing parents increasingly involved in the day-to-day decisions and processes of their students (Coburn 2006; Lum 2006; Hunt 2008; De Stasio et al. 2009). The term “helicopter parents” has been applied to those who hover over and around their children, ready to intervene at a moment’s notice (called upon or not), beyond childhood and into their collegiate careers (Daniel et al. 2001). Helicopter parents are an extension of the protectionist attitudes that Baby Boomer parents sheltered their children with throughout life. Invited or not, they frequently intervene in their college students’ lives, de-
manding access to confidential student accounts, grades, bills, attendance records, and standing. Though many professors and administrators in higher education find such meddling to be anywhere from highly inappropriate to downright illegal, there is evidence that Millennials do not share this perspective. Shoup et al. (2009) conducted a national study that found that students with highly involved parents “exceled in many areas,” including students’ perceptions of gain and engagement, and that students did not identify parental involvement as problematic. However, the same study found that students with highly involved parents posted lower grades (Shoup et al. 2009). A 2007 study found that the average college student communicates with his parents 10 times per week (Kennedy and Hofer 2007), and another found that students on the whole welcomed a high level of parental involvement in their collegiate lives (Hoover 2008).

Confident

Millennials are generally confident in their academic abilities, at times perhaps overconfident. For example, in 2006 over 60% of entering college freshmen expected to receive at least a “B” average at university (Pryor et al. 2006), and another study noted that 69.5% of freshmen ranked themselves in the top 10% of their class—an obvious statistical impossibility (Sax et al. 2002). The Millennials’ high opinion of their academic prowess is most likely the result of grade inflation at both the primary and secondary levels, where instructors are under pressure to simply move students through the educational pipeline (Zemke 2001). Unfortunately, this means that many students of this generation are accustomed to academic success with little effort, which may lead to naïve perceptions concerning the rigor of courses and effort demanded of them in college. In fact, upon matriculation, Millennials require more remediation than any generation before them (Parker 2007; Pryor et al. 2008).

Pressured

Overall, Millennials exhibit a consumerist attitude toward education (Zemke 2001), believing that because they are paying they are entitled to results regardless of performance (Taylor 2005). This attitude frequently brings them into conflict with professors who see these students as petulant and whiny. However, Millennials and their Boomer parents exhibit increasingly aggressive attitudes toward education, using both social and legal forums to demand changes in higher education (Zemke et al. 2000). Unfortunately, the pressure applied to Millennials by their parents and themselves has led many students of this generation to experience levels of stress that result in debilitating consequences for the student. This generation demonstrates an increase in both physical and psychological challenges that present themselves in increased absences or extended times away from school to treat their respective physical and emotional health issues (Howe and Strauss 2003). Also, because of the heightened pressure to achieve, this generation is less likely to see plagiarism and other forms of academic misconduct as moral breaches.

Team Oriented

Millennials are social, technologically savvy, and more group oriented than previous generations, but they are also very keen on personal achievement and recognition. Social dynamics shape how Millennials choose their classes, majors, and friends—virtually every decision they make is colored by the underlying context of social grouping (Zemke 2001; DeBard 2004; Taylor 2005). Technology is also an integral part of Millennials’ lives. They were raised in an era of personal computers, video games, mobile phones, iPods, and the Internet. Researchers have variously classified this generation from highly technologically literate to technologically dependent (e.g., Weilenmann and Larsson 2001; Oblinger and Oblinger 2005; Mangold 2007; Sandars and Morrison 2007). Millennials use technology to stay in near constant contact with their friends and family via vehicles like Facebook and text messaging. The melding of technology with group organization and friendship dynamics has also led to an element of cold impersonality in relationships where one can be “de-friended” at the click of a mouse, rumor spreads instantly, cyber-bullying thrives, and the ever-shifting sands of adolescent friendship turn on positively Machiavellian dynamics.

Conventional

Until recently, the social perception of the American college student has been that of a rebellious young adult, full of idealism, and on “fire” to challenge and change the world. Millennials tend to be the antithesis of this concept. They tend to outwardly respect and revere authority, especially structured authority, but as a group implicitly condone breaking rules as long as one is not caught (Newton 2000; Taylor 2005). The social pressures that Millennials subject themselves to encourage conformity and elements of groupthink, such as minimization of conflict, with an emphasis on consensus (Janis 1972). Millennials are very calculating in the risks that they are willing to take, carefully weighing the pros and cons of decisions. In some ways, this generation is far more mercenary than previous collegiate cohorts. Idealism has given way to the realization that “greed is good,” that to access the corporate world they need to fit in, and therefore they mimic the behaviors, attitudes, and even dress of their parents generation, even though they may not share their values or morals.

Achieving

Students of today’s generation view education fundamentally differently than previous ones. They are used to achieving success at the primary and secondary levels (Sax 2003; Wilson 2004) and expect to be successful in college and the workforce. The self-image of a Millennial student is predicated as much on successful competition against others as evolved introspection. These students want and expect to be recognized for their
achievements, which is likely an outgrowth of being constantly told that they are special. They attain validation through recognition of their accomplishments, even if those accomplishments are what previous generations would consider normal benchmarks, unworthy of celebration. For many Millennials education is not about learning but rather about personal achievement and securing credentials for employment. As a result, they are often perceived as being fixated on grades and as having little tolerance for those subjects or ideas not directly applicable to the job market (Nathan 2005; Taylor 2005).

**Implications for Education**

We've depicted that today's students are very different in many ways from the underclassman of the past; however, there are several opportunities for higher education to address some of the unique characteristics that Millennial students exhibit to better meet their needs while simultaneously providing a quality education. Due to their highly sheltered upbringing, Millennials are more likely to complain about perceptions of unfair grading in the classroom (Howe and Strauss 2000). To avoid allegations of impropriety, educators should clearly and purposefully articulate their expectations for assignments and exams, as well as provide detailed guidance to students if their work is erroneous or incomplete. Similarly, Millennials are also more in tune with the student–faculty dynamic. Any student–faculty interactions that could be construed as providing one student with an advantage over another will likely be perceived as being inappropriate (Howe and Strauss 2000). Faculty impartiality (e.g., announcing personalized internships publically rather than targeting key students) may be critical to creating a sense of fairness for these students. Millennials as a group are obsessed with grades. It is from this that they derive validation and worth, so academic programs may wish to spend time developing rapid feedback mechanisms (Howe and Strauss 2000). This may include the swift turnaround of graded materials, as well as making grades readily available through online course management systems.

The confidence that Millennials exude, especially about their future, may lead them to see less benefit in attempts to be creatively different from their peers (Howe and Strauss 2000). Because they expect to be successful, they may be less likely to “push the envelope.” As a result, Millennials may require more in-depth tutelage as to the worth and value of individual and experimental research. Demonstrating the benefit of individual work is bait that Millennials will follow. Similarly, to recruit students, natural resources programs must demonstrate their worth. Programs can make themselves more attractive by clearly illustrating how graduates may influence and guide potential global and social evolution regarding natural resources. Millennials revere heroes who advocate for social justice and change, and a program that can make them feel like they are a part of that change will be successful. Millennials are likely to need more guidance because they have difficulty with independent decision making, probably as a result of their sheltered lives. Academic programs should consider providing Millennials with bounded course choices (i.e., a small number of courses to choose from to meet a requirement) rather than a long “laundry list” of possible options.

Academic programs should embrace the technologies and formats preferred by today’s students (e.g., podcasts, digital textbooks). As Goodwin-Jones (2005:17) notes, the benefits of using digital technologies “… point not only to such obvious by-products as computer literacy, communicative skills, and community building, but to less immediately evident benefits like identity creation, collaborative learning, or even mentoring.” For example, the use of MP3 players to stream lectures has been shown to be an important strategy for students in accessing information (Shannon 2006).

Millennials will have a high level of respect for the academic institution (Howe and Strauss 2000); that high level of respect transfers to the college professor, and a failure of faculty to meet expectations can result in students quickly losing respect for their instructors—a respect that is difficult to earn back. Faculty should be forthright and honest with students and be ready to admit when they do not know. Given the rapidity of access to online resources, Millennials are quick to check facts and challenge information they know or believe to be erroneous. They will respect the faculty’s honesty but will not forgive condescension or arrogance.

**Implications for Fisheries Conservation**

As with higher education, the fisheries profession must be poised to address the expectations of the Millennial Generation for a productive and valued workplace. Unfortunately, the pressure to excel for Millennials will not be tempered by a realistic opinion of their own skills and abilities and will (ironically) make this group more likely to be defined as “risk taking” within the fisheries profession. Because they are so confident, yet needy of explicit goals and instructions, Millennials may be best served in a workplace that engages in structured mentoring. Mentoring may help temper Millennials’ inherent confidence and discourage them from engaging in risky behaviors such as making decisions without the appropriate evidence and skills. Mentoring promotes open dialogue and the exchange of ideas and may allow the multiple generations present within the fisheries profession to generate more inclusive solutions to the complex natural resources issues of the profession.

Fisheries management is complex and often overwhelming, and Millennials like things simple and clearly defined. This will be challenging for these new professionals. It will be incumbent upon current fisheries professionals and the American Fisheries Society to guide the Millennial generation in (1) developing the skills and “know-how” to make decisions on their own, (2) encouraging them to accept their own responsibility for having made those decisions, and (3) learning how
to rebound from failure when it occurs. Because they are generally so social, Millennials will likely quickly embrace the use of teams to tackle complex problems, and this strategy should continue to be employed in the workplace. The potential for successful collaboration and cooperation is high with this generation, and workplace environments should recognize and embrace this as a possible strategy for success. Drawing on the viewpoints, skill sets, and knowledge bases of many individuals often brings about more comprehensive and sound solutions.

Identifying and adopting emergent technologies is required. Millennials will expect to have access to, and use of, technology. It should also be considered that Millennials will likely expect immediate responses to adopted communications strategy (e.g., emails, text messages, Facebook, Twitter). It is critical that employers and the American Fisheries Society work with Millennials to help them understand the generational difference in effective communication. Strategies to effectively communicate with each other within the workplace and throughout the profession will be necessary to meet the differing preferences of the different generations. Both older and newer professionals need to accept and understand this fundamental difference. Additionally, Millennials will likely rapidly advance the use of digital tools among the current workforce, leading to improved organizational efficiency, more ready access to global fisheries data and information, and increased communication among the diverse stakeholder and client base. All of these advances may lead to more swiftly discovering and assessing problems and issues. Utilization of instantaneous access to new information could allow for great responsiveness to issues of ecological (i.e., oil spill, hurricane) and political significance (i.e., new bill proposed, new laws passed).

**SUMMARY**

The pressures and expectations exerted by a new generation of students on higher education and the fisheries profession are challenging yet create many new and exciting opportunities for change that will ultimately benefit universities, the workplace, and the future of fisheries conservation. Millenbah and Wolter (2009) state that a “failure to understand the background and values of the Millennial generation, as they come of age, will create professionals and a profession increasingly out of touch with the public it serves.” As such, it is necessary for universities to modify their mode of teaching so that it best addresses the attributes of the Millennial generation and fully engages them in meaningful and purposeful learning. Similar strategies should be adopted by the workplace. Understanding and embracing the Millennial Generation’s unique and valuable characteristics will have widespread implications for the future success in fisheries conservation and management.

**ACKNOWLEDGMENT**

Special thanks are extended to K. Mueller and K. Schlee for earlier reviews of this work.

**REFERENCES**


Campus 8:15–20.


Shannon, S. J. 2006. Why don’t students attend lectures and what can be done about it through using iPod nanos? Proceedings of the 23rd Annual ASCILITE Conference.


From the Archives

“I lately witnessed the manner with which the saw-fish use their saws, while in Clearwater harbor. Several young saw-fish, not more than two and a half feet long, were observed in the water where it was only a few inches deep. When they saw me they ceased swimming, and remained on the bottom, where, by a gentle motion of their fins, they were nearly obscured by the sand which settled upon them. Imagining themselves secure, while thus covered, they permitted me to approach near enough to spear one. The wounded fish immediately elevated its head out of the water, thrusting the saw back, and moved it about, seeking for an enemy. Having felt the handle of the wood, the saw-fish at once pulled its saw against it, using much force, and repeating the operation rapidly, always pulling, never pushing. It thus cut gashes in the handle. Two other saw-fishes performed the same operation when speared. None of them permitted an approach until it had partly concealed itself in the sand.”

Mr. Willcox, Transactions of the Thirteenth American Fish-Cultural Association, 1884
Inland Fisheries Management in North America, Third Edition

Edited by Wayne Hubert and Michael Quist

This book describes the conceptual basis and current management practices for freshwater fisheries of North America. This third edition is written by an array of new authors who bring novel and innovative perspectives. The book incorporates recent technological and social developments and uses pertinent literature to support the presented concepts and methods.

Covered topics include the process of fisheries management, fishery assessments, habitat and community manipulations, and the common practices for managing stream, river, lake, and reservoir fisheries. Chapters on history, population dynamics, assessing fisheries, regulation of fisheries, use of hatchery fish, and the process and legal framework of fisheries management are included along with innovative chapters on scales of fisheries management, communication and conflict resolution, managing undesired and invading species, ecological integrity, emerging multispecies approaches, and use of social and economic information.

The book is intended for use in fisheries management courses for undergraduate or graduate students, as well as for practicing fisheries managers.
I don’t want this to turn into a rant. My purpose is to bring our attention to and reinforce the mission of AFS as stated in our most recent strategic plans—to advance sound science, promote professional development, and disseminate science-based fisheries information for the global protection, conservation, and sustainability of fisheries resources and aquatic ecosystems. We don’t need to resort to ranting and discrediting of belief systems to support fisheries and aquatic science and appropriate management activities regarding aquatic ecosystems. Let’s make sure to enhance our reputation for doing sound science by publishing sound science in our journals and presenting sound science at our meetings and using credible scientific information appropriately in policy and management decisions. All of this will assure our professional credibility. I believe that scientific credibility will lead decision makers and politicians to more frequently seek the counsel of fisheries scientists in the not-too-distant future. I acknowledge that I hold this belief without absolute proof, but I would be willing to bet on it.
## Calendar: FISHERIES EVENTS

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

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

More events listed at [www.fisheries.org](http://www.fisheries.org)

<table>
<thead>
<tr>
<th>DATE</th>
<th>EVENT</th>
<th>LOCATION</th>
<th>WEBSITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun 12–18, 2011</td>
<td>First International Conference on Fish Telemetry</td>
<td>Sapporo, Japan</td>
<td><a href="http://www.knt.co.jp/ec/s011/icft">http://www.knt.co.jp/ec/s011/icft</a></td>
</tr>
<tr>
<td>Aug 1–4, 2011</td>
<td>Sixth World Recreational Fishing Conference</td>
<td>Berlin, Germany</td>
<td><a href="http://www.worldrecfish.org">http://www.worldrecfish.org</a></td>
</tr>
<tr>
<td>Sep 22–24, 2011</td>
<td>Icelandic Fisheries Exhibition 2011</td>
<td>Smarinn, Kopavogur, Iceland</td>
<td><a href="">ftp://www.icefish.is</a></td>
</tr>
<tr>
<td>Nov 6–11, 2011</td>
<td>Coastal and Estuarine Research Federation Conference</td>
<td>Daytona Beach, Florida</td>
<td><a href="http://erf.org">http://erf.org</a></td>
</tr>
</tbody>
</table>
June 2011: JOBS

POST-MASTERS RESEARCHER | PACIFIC NORTHWEST NATIONAL LABORATORY, WA | PERMANENT

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

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

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

Contact: Apply: Please visit below link and reference job posting 300817
Web Link: http://www.jobs.pnl.gov

GRADUATE RESEARCH POSITIONS | CENTER FOR QUANTITATIVE FISHERIES ECOLOGY, OLD DOMINION UNIV | STUDENT

Salary: $24,000
Closing: Until filled

Responsibilities: Work as part of a collaborative research team on one of several funded projects evaluating the use of otolith chemistry to track dispersal, evaluate habitat use, and identify factors regulating recruitment in estuarine dependent fishes. The student will be expected to develop their own thesis or dissertation from this work. Students will also perform database management and data analysis, and will assist in writing annual reports to granting agencies. This position is available immediately.

Qualifications: Applicants should have a B.S. or M.S. in an appropriate discipline and be self-motivated with an interest in pursuing a career in fisheries management or research. Strong written and verbal communication skills. Experience performing data analysis highly desired. Calculus is required for admission.

Contact: Submit the following to Dr. Cynthia M. Jones at below email cover letter, curriculum vitae, unofficial transcripts, GRE scores, and contact information for three references to below email.
Web Link: http://www.odu.edu/sci/cqfe
Contact Email address: cjones@odu.edu

FISHERIES POLICY ANALYST | ENVIRONMENTAL DEFENSE FUND | PERMANENT

Salary: TBD
Closing: Until filled

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

Qualifications: For full job description and application instructions please follow the link provided below.
Web Link: http://www.edf.org/page.cfm?tagid=371&jobID=655
Contact Email address: jobs@edf.org

FISH CULTURE STATION MANAGER | PA FISH AND BOAT COMMISSION | PERMANENT

Salary: $41,429 - $62,964
Closing: 6/11

Responsibilities: Responsible for all hatchery operations. They develop and manage annual budgets based on assigned fish production goals direct fish culture operations supervise maintenance and repair of buildings, grounds, and equipment prepare work schedules, purchase orders, requisitions, and operational reports and implement educational and public information programs.


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.
**Graduate Assistantship | Dept of Wildlife, Fisheries and Aquaculture, MI State Univ |**

**Salary:** $16,000 annual stipend, plus full tuition and health insurance for 2 years.

**Closing:** 6/30

**Responsibilities:** Graduate Assistantship in Pond Aquaculture. The Dept of Wildlife, Fisheries and Aquaculture at Mississippi State University seeks a highly qualified student for a masters graduate research assistantship in Pond Aquaculture. The research assistantship will focus on furthering our understanding of water quality and production dynamics of a newly established management system for boosting catfish production in the South-Eastern United States. The qualified candidate will work closely with MSU scientists as well as researchers at the National Warmwater Aquaculture Center in Stoneville, MS. Qualified candidates would be introduced to important researchers in federal and state agencies and be willing to be involved in a young, exciting, cutting-edge aquatic research program.

**Qualifications:** B.S. in appropriate discipline. Demonstrated excellence in coursework, good written and oral communication and importantly have the ability to work as a team member is required. An enthusiastic and vibrant individual will have high standing in qualification criteria. Applying candidates pre-requisites include a cumulative GPA greater than 3.0 in undergraduate coursework, and a GRE score over 1000.

**Contact:** Dr. Robert Kroger, 662 325-4731

**Contact Email Address:** rkroger@cfr.msstate.edu

---

**Makah Watershed Scientist | Makah Tribe, WA | Permanent**

**Salary:** Competitive Salary

**Closing:** Until Filled

**Responsibilities:** This position is responsible for developing, coordinating, and implementing habitat research, monitoring, and protection efforts associated with the implementation of the Puget Sound Partnership Action Agenda throughout the Makah U A. It will also focus on the implementation of the Lake Ozette Sockeye Recovery Plan priority restoration projects while maintaining and improving the existing streamflow and water quality monitoring network in the Lake Ozette Watershed.

**Qualifications:** M.S. degree in fisheries biology, aquatic ecology, aquatic biology, or closely related field. General knowledge of anadromous species. Strong quantitative and writing skills. Physical experience/ability to collect field data e.g., fisheries, water quality, surveying, hydrology. Ability to work closely with resource agencies, tribes, and other interested parties in meeting recovery goals and objectives.

**Contact:** The Makah Tribe is an Equal Opportunity Employer. **Web Link** below Contact for specific questions email or 360-645-3155 or 360-645-3200

**Web Link:** http://www.makah.com

**Contact Email Address:** mtcpersonnel@centurytel.net

---

**Ecological Restoration Specialist | Stratus Consulting, CO. and D.C. | Permanent**

**Salary:** Stratus Consulting offers a competitive compensation and benefits package that includes medical, dental, vision, and life insurance, 401 k and profit-sharing plans, medical and dependent care, flexible spending accounts, paid time off, business casual dress, and more.

**Closing:** Until filled

**Responsibilities:** Stratus Consulting provides innovation and excellence in environmental research and consulting. It offers comprehensive, multidisciplinary expertise in environmental sciences and natural resources, environmental economics, information management, and climate change management. Stratus Consulting serves federal, state, tribal, and international government agencies, as well as utilities, industries, and law firms. Responsibilities include: Developing ecological restoration plans for a broad range of natural resources, including fauna, flora, and habitats Coordinating ecological restoration planning initiatives with natural resource injury assessments Preparing technical documents Project management and Client communications.

**Qualifications:** Qualified applicants will possess MS/PhD in relevant field and a minimum of 5 or more years of directly relevant experience

**Contact:** For immediate consideration, please apply via the Careers Section of the Stratus Consulting website below. If you are unable to apply via our website, please mail or fax a cover letter reference job code Eco-Sci, salary expectations and current resume to below email. fax: 303-381-8200 mail: PO Box 4059 Boulder, CO 80306-4059 Calls will not be accepted. EEO/M/F/D/V

**Web Link:** http://www.stratusconsulting.com

**Contact Email Address:** hr@stratusconsulting.com
Tanks, Chiller Units and The “Living Stream” System

RECTANGULAR TANKS
available in various sizes or
custom built to your requirements

CIRCULAR TANKS
Available in various sizes from 3' to 8' diameters. Insulated or non-insulated depending on your temperature requirements.

WATER CHILLER UNITS
COOL, AERATE & CIRCULATE IN ONE OPERATION (HEATING OPTIONAL)

The “LIVING STREAM” System
Provides a controlled environment for aquatic life.

The Living Stream is a revolutionary design of recirculating water in a closed system. All the water in the insulated tank makes a complete cycle every 1-1/2 minutes, thus providing an equal amount of dissolved oxygen and the desired temperature throughout the entire tank.

5072 Lewis Ave. Toledo, OH 43612
Phone: 419.478.4000
Fax: 419.478.4019
www.frigidunits.com

Your Tags Your Way

FLOY TAG
The World Leader & Innovator in Fish Tags - For Over 50 Years

Shellfish, Lobster & Crustacean Tags
T-Bar Anchor Tags, Spaghetti Tags, Dart Tags & More
Net, Trap & Line Tags
Laminated Disc and Oval Tags
Dart, Fingerling, Streamer, Intramuscular Tags
Guns and Tag Applicators, Extra Needles, etc.

...and almost any other kind of custom tagging solution you might need.

"Why Risk Your Research To The Copy-Cats ...When You Can Have The Original?"

View our latest catalog at www.floytag.com, or email us at: sales@floytag.com or call to discuss your custom tagging needs: (800) 843-1172
Our transmitters aren’t as interesting as what researchers put them on.

But, they are more reliable.

ATS offers the smallest, longest lasting fish transmitters in the world; VHF, acoustic and archival. We provide complete tracking systems, including receiver/dataloggers, antenna systems and more. Plus, our coded system virtually eliminates false positives from your data set, providing you with 99.5% accuracy, a level not available from any other manufacturer.

Contact ATS for details.
Hello from Seattle,
You’re still coming to see us this summer, right?
We’re all going to the party at the Seattle Aquarium — you know, the one hosted by the AFS students and HTI Sept. 6th...we sure hope you are, because it isn’t a party without you!

P.S. John says hi!

AFS 2011 Attendee
715 NE Main Street
Hometown, USA

Washington