Conserving Peripheral Trout Populations: the Values and Risks of Life on the Edge

California Golden Trout: Perspectives on Restoration and Management
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Fish species preservation goes back a long way. California’s efforts to preserve the golden trout began more than a century ago in the era of Theodore Roosevelt and continue today.

Edwin P. (Phil) Pister

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Conserving Peripheral Trout Populations: the Values and Risks of Life on the Edge

Our characterization of peripheral populations and their losses emphasizes the need for closer evaluation of conservation priorities and management actions for cutthroat trout and other fishes if the values of peripheral populations are to be maintained.

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California Golden Trout: Perspectives on Restoration and Management


Credit: Edwin P. (Phil) Pister.
Let me tell you a story. It is late March, ice is melting from the lakes and there are hints of green along the shoreline, but the wind is blowing and there is sleet in the air. A 1980s vintage compact pulls into the parking lot of the District Fisheries Office, a large metal building with a small office at one end, a large garage at the other, and a chain-link fence enclosing some boats, camper trailers, and pickup trucks. A young fellow extracts himself from the car and dashes into the office to get out of the wind. There is nobody in the office, but there are signs of life. The computer monitor lights up a desk covered with papers, books, and a half-full coffee cup. The wall behind the desk supports numerous photos of a variety of fish being held by a guy with an appealing smile. Among the photos are four picture frames, one holds a bachelors of science degree in fisheries and wildlife biology from the state university, a second holds a master of science degree from the same school, a third is a certification of a professional fisheries scientist, and a fourth says something about 20 years of service to the state agency.

The door from the garage opens and in walks a middle-aged man in a uniform shirt who says,

**You must be the seasonal tech. Welcome! The guys at the head shed tell me you’re OK and quite a communicator. You sure impressed them during the interview.**

They share a cup of coffee and exchange pleasantries for about an hour, mostly reminiscence by the district biologist of his fishing and hunting experiences on the nearby lakes. They learn that they both hold degrees from the state “U“ and they chat a little about the football team. Then the district biologist asks why the young fellow has taken a seasonal job when he has a master’s degree. The tech responds that the recession has reduced the availability of jobs and he had to take what he could get with the hope of having a foot in the door for a permanent position. The chatter eventually turns to the reality of life, work.

The district biologist says,

**The first thing we need to do is get ready for our annual trend netting starting next week. That means, making sure the big John boat is ready to go and the gear is up to snuff. You will need to back the big boat into the garage, check the foot grease, grease the wheel bearings, charge and install the battery, and fix the trailer lights if they aren’t working. Then, go to the lake with the boat and make sure it is good-to-go. When you get back, pull out the experimental gill nets and trap nets, and make sure they are clean and mended. Muskrats got into a couple last year and chewed them up pretty badly.**

The young tech looks dumbfounded and doesn’t know what to say. The district biologist quickly recognizes the tech’s distress and changes the subject.

**Tell me, what kinds of things did you do when you went to summer camp?**

The tech responds,

**They cut that out before I started at the U.**

**Did you do an internship or have a summer job?**

The tech responds,

**Sure did. I had an internship with the Nature Conservancy and helped them with their GIS coverages. I worked one summer in the state office of the Fish and Wildlife Service where I helped set up databases with endangered species information. Another summer I worked with a grad student. I prepared fish tissue for stable isotope analyses and entered data.**

**OK? What were the fisheries courses you took at the U?**

The tech shuffled in his seat and answered,

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As part of the arrangement with our new publishing partner Taylor & Francis, AFS journals will soon switch to ScholarOne Manuscripts for all newly submitted manuscripts.

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is an adaptable, user-friendly online submission and peer-review database. It allows for rapid submission of original and revised manuscripts, as well as facilitates the review process and internal communication among authors, editors, and reviewers via a web-based platform. It is a market leader in web-based scholarly publishing, which is currently evidenced by statistics of over 13 million registered users, and receives over 100,000 submissions a month world-wide. It can be accessed via any web browser at any time.

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- Facilitate sharing of data across large spatial areas

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- Determine funding levels for monitoring programs
- Design monitoring programs or analyze their resulting data
- Implement monitoring programs in the field
- Use results of monitoring programs to make decisions

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Developed by a team of 14 North American scientists from Alaska through California under a grant from the Gordon and Betty Moore Foundation, with assistance from the National Center for Ecological Analysis and Synthesis (NCEAS)
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Announcing our sale on backpack electrofishers and combos. Our advanced LR-24 and versatile LR-20B discounted from November 1st through February 28th.

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Make sure to take advantage of both of these great deals!
NOAA Fisheries Service proposes new sturgeon protections

NOAA Fisheries Service has proposed that five populations of Atlantic sturgeon along the US East Coast receive protection under the federal Endangered Species Act.

The Gulf of Maine population is proposed for listing as threatened, and endangered status is proposed for the Chesapeake Bay, New York Bight, Carolina, and South Atlantic populations. Historically, their range included major estuary and river systems from Labrador to Florida. Because the marine range of an individual sturgeon can be very broad regardless of where it originated, threats along the East Coast can affect fish from any of these populations.

The proposed protections stem from a formal status review that was completed for the Atlantic sturgeon in 2007 by a team of biologists from NOAA, the US Geological Survey, and the US Fish and Wildlife Service. The review found that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, dams, lack of regulatory mechanisms for protecting the fish, and dredging were the most significant threats to the fish. It is currently illegal to fish for, catch, or keep Atlantic sturgeon from US waters.

NOAA Fisheries Service is seeking comments on the proposed listing through January 4.

Comments can be submitted on the Federal eRulemaking Portal at www.regulations.gov.

EU proposes no increase in deep sea fishing

The European Commission has recently proposed not to grant increases in fishing opportunities for deep-sea fish in EU waters and in international waters of the North-East Atlantic for 2011-2012 until positive trends in the abundance of deep-sea stocks have been properly identified. The proposal for 2011 and 2012, based on scientific advice, will bring the Total Allowable Catch in line with advised precautionary catch levels.

The scientific advice was received from the International Council for the Exploration of the Sea (ICES) and the Scientific, Economic and Technical Committee for Fisheries (STECF).

NOAA Fisheries Service announces $12.6 million in grants to states to support threatened and endangered species recovery

NOAA Fisheries Service has announced $12.6 million in grants through the Protected Species Cooperative Conservation Grant Program to assist 19 states and territories with conservation projects designed to recover marine mammals, sea turtles, fish, coral, and other species listed under the Endangered Species Act.

Sixteen proposals were chosen from a pool of 35 applications. The competitive grant program supports management, research, and outreach efforts designed to bring listed species to the point where ESA protections are no longer necessary. In addition, the program also supports monitoring efforts for species proposed for listing, recently de-listed species, and candidate species.

Some of the proposals selected include:

- California Department of Fish and Game ($442,510): To develop and implement restoration tools (such as captive breeding and release) to recover the critically endangered white abalone.
- Delaware Division of Fish and Wildlife ($1,019,486): To determine habitat requirements and migratory pathways to provide managers with essential information to recover Atlantic and shortnose sturgeon in Delaware, New Jersey, and Connecticut.
- Florida Fish and Wildlife Conservation Commission ($1,432,320): To monitor and map threatened acroporid corals in U.S. waters and enhance coral conservation programs with the U.S. Virgin Islands and Puerto Rico offices.
- Florida Fish and Wildlife Conservation Commission ($779,985): To conduct research and develop outreach materials with Texas partners to assist in the recovery of smalltooth sawfish throughout Florida and the Gulf of Mexico.
- Hawaii Department of Land and Natural Resources ($493,761): To reduce shoreline disturbances and nearshore fishery interactions (e.g., entanglement and hooking) and continue long-term management of Hawaiian monk seals and sea turtles.
- New York Department of Environmental Conservation ($1,325,437): To collaborate with Maine, Connecticut, and New Jersey partners in determining Atlantic sturgeon habitat use and movement throughout the Mid-Atlantic Bight and evaluating spatial strategies to minimize Atlantic sturgeon bycatch.
- Virginia Department of Game and Inland Fisheries ($1,425,959): To enhance conservation and management of sea turtles in Chesapeake Bay and Virginia’s ocean waters through collection of a comprehensive set of data on the life history, health, and abundance of resident sea turtle species.
- Washington Department of Fish and Wildlife ($576,668): To collaborate with the Oregon Department of Fish and Wildlife in tracking coast-wide status and trends of green sturgeon and managing human caused impacts to the species.
- Washington Department of Fish and Wildlife ($561,579): Working with the Oregon Department of Fish and Wildlife to monitor eulachon smelt abundance and distribution and evaluate fishing techniques to reduce smelt bycatch.

More information about Protected Species Cooperative Conservation Grants can be found at www.nmfs.noaa.gov/pr/conservation/states/.

Elden Hawkes, Jr.
AFS Policy Coordinator Hawkes can be contacted at ehawkes@fisheries.org.
A Seabass Revival

Once a rare catch, the white seabass (Atractosteus nobilis) is resurging from severe depletion with the help of a unique program at Hubbs-SeaWorld Research Institute (HSWRI) in California, USA. In 1983, the Ocean Resources Enhancement and Hatchery Program began with the goal of raising white seabass for ocean release, and is one of only a few marine finfish stock enhancement programs in the world.

HSWRI scientists first learned to spawn the fish in captivity and rear the delicate larvae. This process is highly successful—production is 350,000 juveniles annually, with plans for 1 million. A combination of direct and net pen year-round releases are used after about 3 months of hatchery rearing. For net pen releases, the juveniles are transferred to 13 saltwater grow out facilities along the coast. They are released several months later at about 20 cm long.

Before release, each fish is tagged in the cheek with a Coded Wire Tag (CWT). The CWT is used to distinguish hatchery-reared from wild fish after release, evaluate hatchery rearing practices, and monitor how well the fish are surviving in the wild. To help HSWRI retrieve the tags, fishers are asked to save the heads of white seabass caught off the California coast and to deposit them at various drop-off locations. More than 1,800 tagged fish have been recovered since the start of the program with anglers recovering some fish 13 years after release.

The CWT program provides much information that benefits seabass enhancement. For example, tag recoveries showed that releasing juveniles from net pens is more effective than direct releases. The hatchery is reorganizing production and release strategies to maximize survival and subsequent recruitment to the fisheries.

NMT is proud to be part of this project and hundreds of others around the world. Please contact us if we can help with yours.
ABSTRACT: Peripheral populations—generally defined as those at the geographic edge of the range—often have increased conservation value due to their potential to maximize within-species biodiversity, retain important evolutionary legacies, and provide the fodder for future adaptation. However, there has been little exploration of their conservation value in aquatic systems. Inland cutthroat trout (Oncorhynchus clarkii) subspecies provide a unique opportunity to evaluate the distribution of peripheral populations and patterns of persistence across a wide range of environmental conditions. Our assessment analyzed range-wide losses of peripheral and core populations since the 1800s, and evaluated the likelihood of persistence for remaining populations of five cutthroat trout subspecies: Bonneville, Colorado River, Yellowstone, Rio Grande, and westslope. For all five, we found that core and peripheral populations have declined substantially, but the amounts of habitat occupied by peripheral populations generally have declined at a greater magnitude. The more isolated peripheral populations typically exhibited the greatest declines. Remaining peripheral populations often failed to meet minimum persistence criteria. Our characterization of peripheral populations and their losses emphasizes the need for closer evaluation of conservation priorities and management actions for cutthroat trout and other fishes if the values of peripheral populations are to be maintained.

Introduction

The conservation of population diversity is imperative to the conservation of species (McElhany et al. 2000; Luck et al. 2003; Gustafson et al. 2007), which has created a need to prioritize populations deserving management attention. Whereas there are many aspects of populations to consider, the conservation of peripheral populations has received increasing attention in the conservation biology literature. Peripheral populations can be defined generally as those at the geographic edge of a species’ range, though their attributes can be quite different depending on whether they are continuous with, or disjunct from, the rest of the range (Bunnell et al. 2004). From a conservation perspective, peripheral populations are often assumed to have certain characteristics that may increase their value for maximizing within-species biodiversity and species persistence. Peripheral populations are generally more isolated than populations closer to
the core of a species range, and are often assumed to occupy marginal habitat and have lower abundances (but see Sagarin and Gaines 2002; Sagarin et al. 2006). As a result, peripheral populations should experience increased genetic drift and selective pressures, which may be expected to cause a suite of unique and potentially adaptive genetic characteristics unlikely to be found in larger, more stable populations (Lesica and Allendorf 1995; Nielsen et al. 2001). Many peripheral populations also have had a unique history during recent glacial periods, either being derived from refugia (Nielsen 1999; Hampe and Petit 2005), or acting as the leading edge of colonization following glacial retreats (Taylor et al. 2003). Consequently, it is often argued that peripheral populations merit higher conservation priority because collectively they maximize within-species diversity, retain an important evolutionary legacy, and provide the fodder for future adaptation and speciation (Lesica and Allendorf 1995; Nielsen 1999; Nielsen et al. 2001).

Peripheral populations may also become increasingly important for species persistence in light of on-going human impacts (e.g., land development and the introduction of nonnative species) as well as in the context of climate change. As air temperatures increase with global climate change, peripheral populations farther from the Equator are likely to provide the leading edge for range shifts, and protection of these populations and their habitats may provide essential stepping stones as species attempt to track their changing environment (Gibson et al. 2009). Populations at the trailing edge of range shifts may also be important because they may harbor unique genetic diversity or adaptations that could be beneficial in a changing climate, such as higher temperature tolerances (Flebbe et al. 2006; Beatty et al. 2008). Thus, there may be a variety of reasons for prioritizing at least some peripheral populations along the entire edge of a range, and a general strategy of preserving populations across the environmental gradients experienced by a species may be our best bet for maximizing future adaptive potential (Smith et al. 2001; Moritz 2002).

Evaluating conservation needs with respect to peripheral populations in fishes is difficult because it requires data from multiple systems that have not been fully represented in research on peripheral populations (see Hampe and Petit 2005). The inland cutthroat trout (Oncorhynchus clarkii) subspecies of the western United States provide a unique opportunity to evaluate the distribution of core and peripheral populations, reveal patterns of persistence across the ranges of multiple subspecies, and provide rare insight into distributional patterns of aquatic fauna. First, they occupy a wide range of environmental conditions across varying latitudes and are separated by natural geographic dispersal barriers (Behnke 1992). Second, they are also confronted with various human impacts and in general are highly imperiled fauna (Young 1995; Behnke 2002). Our objective was to compare the distribution and persistence of peripheral populations within and among five subspecies of cutthroat trout: Bonneville cutthroat trout (O. c. utah), Colorado River cutthroat trout (O. c. pleuriticus), Yellowstone cutthroat trout (O. c. bouvieri; including the Snake River fine spotted form), Rio Grande cutthroat trout (O. c. virginalis), and westslope cutthroat trout (O. c. lewisii) (Figure 1). Contrasts in the distribution and persistence of peripheral and core populations among subspecies of cutthroat trout could provide insight valuable for prioritizing conservation needs across these fishes’ ranges at a time of rapid environmental change.

Methods

Our assessment analyzed range-wide losses of peripheral populations relative to core populations since the 1800s and evaluated the likelihood of persistence for remaining populations. We first classified historical populations of Bonneville, Colorado River, Yellowstone, Rio Grande, and westslope cutthroat trout as core, continuous peripheral, or disjunct peripheral using a standardized rule set based on hydrologic connectivity and topographic isolation within and among populations. In our approach, core areas have a higher degree of interpopulation connectivity and drain into a common river system, whereas peripheral populations are more disconnected from central river systems. We then analyzed data from the latest available status surveys for each subspecies and compared current distributions to historical distributions to document extirpation of each type of population. Finally, we analyzed the likelihood of persistence for remaining peripheral populations based on fish abundance, amount of occupied stream habitat, and habitat patch size.

Defining peripheral populations based on historical distribution

There are many definitions of peripheral populations but most make a distinction between those that are geographically marginal (distant from the core of the species’ range) and those that are ecologically marginal (occupy a different environment; Lesica and Allendorf 1995; Bunnell et al. 2004). Although geographically marginal populations are often ecologically marginal as well, we rely on a spatial definition because of the difficulty in defining ecological marginality across entire species ranges.

Peripheral populations also differ based on their spatial relationships with core populations. Lesica and Allendorf (1995) used a continuum of spatial distance from the core to assess the relative conservation value of populations that are more or less disjunct. Channell and Lomolino (2000a and b) used an index of centrality to compare populations based on their inclusion in equal area bands within the historical range designating peripheral and central regions. Bunnell et al. (2004) recognized two discrete types of peripheral populations: continuous and disjunct. They defined disjunct populations as being isolated from the core such that genetic interactions are precluded, whereas continuous populations occupy the outer edge of a species’ range. Because the aquatic systems on which we focus have different attributes from the more commonly-referenced terrestrial systems, we used the classifications described by Bunnell et al. (2004) but have modified their methods for distinguishing between disjunct and continuous peripheral populations. We used the historical distribution of each subspecies to define disjunct peripheral populations as those that were not hydrologically connected within the same river basin and therefore with no practical opportunity for gene flow, whereas continuous peripheral populations were connected hydrologically within the same river basin but were at the far downstream extent from the core populations.

We first identified core populations based on a geographic information systems (GIS) analysis of the connectivity of his-
Figure 1. Historical ranges of cutthroat trout subspecies analyzed in this paper.
Historical populations. Hydrologic networks that were spatially discrete from other systems but internally interconnected were identified from the historical distribution, then broken into four classes based on total length of the connected network using a "natural breaks" classification (Jenks 1967). This method identifies groupings of stream networks that minimize variance within groups and maximize variance among groups. All networks in the three groups with highest connectivity were classified as core, whereas the remaining group with the lowest connectivity was further analyzed.

The low connectivity populations were then evaluated to determine if they should be considered part of the core populations. Figure 2 provides a graphical depiction of our population classification. Low connectivity populations within a

Figure 2. Decision tree for determining how historical populations of cutthroat trout were classified as core, continuous peripheral, or disjunct peripheral.
sub-basin (4th Hydrologic Unit Code) that contained core populations were classified as core if they were topographically connected (i.e., occurred along the same mountain range) to core populations. Low connectivity populations within a river basin (2nd Hydrologic Unit Code) containing core populations were classified as core if they were hydrologically connected to the main stem river upstream of a designated core population and drained from the same topographic feature (e.g., mountain range) as a core population. If they drained from an isolated mountain range or connected to the main stem river at the downstream extent of the core they were classified as continuous peripheral. The remaining populations were classified as disjunct peripheral, being low connectivity populations with no hydrologic connectivity to the core.

Spatial data on historical distributions, current population extents, and population sizes were taken from the recent range-wide assessments for Bonneville cutthroat trout (May and Albeke 2005 as updated by the Bonneville Cutthroat Trout Working Group in 2009, pers. comm.), Colorado River cutthroat trout (Hirsch et al. 2006), Yellowstone cutthroat trout (May et al. 2007), westslope cutthroat trout (Shepard et al. 2003), and Rio Grande cutthroat trout (Alves et al. 2007) with supplements in the Texas portion of the range from Garrett and Matlock (1991), and are described in Trout Unlimited’s Conservation Success Index (Williams et al. 2007).

Current distribution and persistence of core and peripheral populations

Using the above framework, we evaluated the current distribution of populations in each category compared to their historical distribution to determine the relative magnitude of losses in each category. We also examined the likelihood of persistence for peripheral populations that were classified as “conservation populations” in the range-wide assessments. Generally, conservation populations were identified in these range-wide assessments as having sufficient genetic purity and habitat to provide conservation value (e.g., Alves et al. 2007). Assessments also contained information on population density and extent of occupied habitat of conservation populations, which facilitates further analysis of their likely persistence.

After identifying those peripheral populations receiving conservation population status, we then determined their likelihood of persistence. Our persistence analysis followed Hilderbrand and Kershner (2000) for small cutthroat trout streams, and Dunham, and Rieman’s (1999) work on bull trout (Salvelinus confluentus) for larger rivers or interconnected stream systems. We integrated the findings of these two studies such that populations occupying both a patch size greater than 5,000 ha and a stream extent of at least 13.9 km were considered persistent. Populations occupying less than 5,000 ha or less than 13.9 km of habitat required certain combinations of stream habitat availability and population density to meet persistence criteria. We generally followed Hilderbrand and Kershner’s (2000) target of a census size of 2,500 individuals (> 75 mm TL), which is assumed to equate to an effective population size of 500 spawning adults, but because the assessment data used in this study report abundances only for individuals 150 mm or longer TL, we targeted an approximate census size of 1,250. Densities reported in the assessments were given in ranges, which we categorized such that “low” = < 31 fish/km, “moderate” = 31–93 fish/km, “high” > 93 fish/km. Using these categories, populations with “moderate” densities occupying 13.9–27.8 km habitat (see Hilderbrand and Kershner 2000), or “high” densities occupying 9.3–13.9 km stream habitat were considered persistent.

Populations occupying greater than 27.8 km of habitat at any density were considered persistent, whereas those with less than 9.3 km of stream habitat did not meet persistence criteria regardless of fish density (Hilderbrand and Kershner 2000).

Results

General distributions and declines

For all subspecies, the majority of historical populations (83–91%) were categorized as core, with the remaining populations falling in the two peripheral categories except for Bonneville cutthroat trout, for which no populations met our criteria for continuous peripheral (Table 1). We found that core and peripheral populations of all five cutthroat trout subspecies have declined substantially since historical times, but the amounts of stream habitat occupied by peripheral populations generally have declined at a greater magnitude. The more isolated disjunct peripheral populations typically exhibited the greatest declines and have been completely extirpated in Rio Grande cutthroat trout. The status of westslope cutthroat trout populations was better when compared to other subspecies, but even here declines of disjunct peripheral populations were nearly twice that of core populations.

Bonneville cutthroat trout occur in four geographic areas mostly in Utah: the Bear River, Northern Bonneville, Southern Bonneville, and West Desert. For Bonneville cutthroat trout, disjunct peripheral populations historically occurred in the Southern Bonneville outside of the Sevier River drainage as well as all occupied habitats in the West Desert (Figure 3). No populations were classified as continuous peripheral for this subspecies. All historical populations in the Bear River and Northern Bonneville areas as well as those in the Sevier River drainage (Southern Bonneville) were classified as core populations. Comparisons to recent surveys (May and Albeke 2007) show declines of 62% for habitat occupied by core populations and 91% for habitat occupied by disjunct peripheral populations (Table 1). Only 124 km of habitat is still occupied by remaining disjunct peripheral populations (Figure 4). Recent translocations of Bonneville cutthroat trout to streams in the West Desert area for conservation purposes have provided an additional 71 km of habitat for disjunct peripheral populations, bringing the total to 195 km. Populations throughout the Southern Bonneville have been severely fragmented and isolated, particularly in the Sevier River drainage, which historically was a relatively intact core system.

Colorado River cutthroat trout exhibited substantial and almost equal declines among all population classes
Historically, core populations of Yellowstone cutthroat trout were prevalent in headwater areas of the Upper Green, Yampa, Lower Green, Upper Colorado, Gunnison, Dolores, and San Juan basins. Comparisons between historical distribution and a recent status review (Hirsch et al. 2006) found substantial declines in all basins (ca. 90%). Remaining stronghold areas are primarily in the Upper Green, Lower Green, and Yampa basins with very few populations remaining in the San Juan and Dolores basins. Historically, peripheral populations in most basins were scattered in lower elevation regions or areas draining from isolated mountain ranges, including all populations in the Lower Colorado (Figure 5). Continuous peripheral populations have declined by 87% and disjunct peripheral populations by 90%, with 440 km of stream habitat remaining for disjunct and continuous peripheral populations combined (Figure 6). The only remaining disjunct peripheral populations are found in the Dolores and Lower Colorado basins.

Historically, core populations of Yellowstone cutthroat trout were widely distributed in four of the five geographic areas inhabited by this subspecies: Bighorn, Yellowstone, Upper Snake, and Lower Snake (Figure 7). Peripheral populations historically occurred primarily along the northern and eastern flanks of the Bighorn Mountains in Wyoming and Montana, including the Tongue River drainage, and in the western and southern-most portions of the Lower Snake basin, primarily in Idaho. Compared to historical distributions, core populations have declined less for Yellowstone cutthroat trout than other subspecies examined except for westslope cutthroat trout, but still approximately half the populations have been extirpated (Table 1). Disjunct peripheral populations have declined by 84% while continuous peripheral populations declined by 86%. Remaining historical peripheral populations are located in Idaho’s Camas Creek drainage, Wyoming’s lower Bighorn drainage, and the Snake River near the Idaho/Utah border (Figure 8). Existing populations of Yellowstone cutthroat trout have been augmented somewhat by translocations that have resulted in 909 km of additional stream habitat, occupied by core and peripheral populations, including disjunct populations in the headwaters of the Tongue River.

All population groups of Rio Grande cutthroat trout have declined substantially, including the extirpation of all disjunct peripheral populations (Table 1). Historically, disjunct peripheral populations were located in isolated portions of the Upper and Lower Pecos River basins in southeastern New Mexico and western Texas as well as the Caballo geographic area of the Rio Grande (Figure 9). Remaining peripheral populations were classified as continuous peripheral and consisted of 89 km of occupied habitat in the Lower Rio Grande geographic area in New Mexico (Figure 10). Rio Grande cutthroat trout have been introduced into 75 km of stream habitat, which were all classified as core.

Disjunct peripheral populations of westslope cutthroat trout historically occurred in the Upper Columbia (Washington), John Day (Oregon), and Musselshell (Montana) drainages (Figure 11). Continuous peripheral populations currently occur in the Idaho/Washington border area of the Coeur d’Alene basin and have shown no declines since historical times (Figure 12). Historical populations in all remaining river drainages were classified as core. Recent assessment data (Shephard et al. 2003) shows substantial disjunct peripheral population losses in all three areas as well as habitat fragmentation and isolation of remaining core populations in the following drainages: Clark Fork, Marias, Middle Missouri, Upper Missouri, and Madison. Remaining populations are now increasingly vulnerable because of the amount of habitat lost and the location of these areas outside of the remaining core. Overall, stream habitat occupied by core populations decreased by approximately 37%, the lowest decline of any subspecies examined, while disjunct peripheral populations declined by 73% (Table 1).

### Table 1. Classification of historical cutthroat trout populations and the fate of these populations since historical (ca. 1850) times. Extent of historical, current, and extirpated populations is given in km of occupied stream habitat. Introduced populations are classified based on the location of the donor population.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Historical (km)</th>
<th>Current (km)</th>
<th>Extirpated (km)</th>
<th>Extirpated (%)</th>
<th>Introduced (km)</th>
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<td>1,252</td>
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<tr>
<td>Core</td>
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<td>26,358</td>
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<td>2,490</td>
<td>329</td>
<td>2,161</td>
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<tr>
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<tr>
<td>Core</td>
<td>22,539</td>
<td>11,202</td>
<td>11,337</td>
<td>50%</td>
<td>791</td>
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<td>473</td>
<td>2,892</td>
<td>86%</td>
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<tr>
<td>Disjunct peripheral</td>
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<td>1,124</td>
<td>84%</td>
<td>87</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Core</td>
<td>9,901</td>
<td>1,138</td>
<td>8,762</td>
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<td>75</td>
</tr>
<tr>
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<td>527</td>
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<td>438</td>
<td>83%</td>
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</tr>
<tr>
<td>Disjunct peripheral</td>
<td>417</td>
<td>0</td>
<td>417</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td><strong>Westslope Cutthroat Trout</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core</td>
<td>83,341</td>
<td>52,221</td>
<td>31,120</td>
<td>37%</td>
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<tr>
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<tr>
<td>Disjunct peripheral</td>
<td>7,242</td>
<td>1,981</td>
<td>5,260</td>
<td>73%</td>
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</tr>
</tbody>
</table>

### Persistence of remaining peripheral populations

The percentages of conservation populations meeting persistence criteria varied widely among subspecies, and between continuous and disjunct peripheral populations (Table 2). Only 6 disjunct populations of Yellowstone cutthroat trout remain, but four of these (67%)
Figure 3. Historical distribution of core and peripheral populations of Bonneville cutthroat trout.
Figure 4. Current distribution of core and peripheral populations of Bonneville cutthroat trout. Note that some populations (shown by dotted lines) have been introduced into previously unoccupied stream segments but still within their historical range.
Figure 5. Historical distribution of core and peripheral populations of Colorado River cutthroat trout.
Figure 6. Current distribution of core and peripheral populations of Colorado River cutthroat trout.
were considered persistent. The majority of continuous peripheral populations have also been extirpated already for this subspecies (Table 1), and though 32 remain, only 6 (19%) were considered persistent. Both continuous and disjunct peripheral populations classified as persistent for Yellowstone cutthroat trout occupy, on average, more than 50 km of streams, considerably more than persistent peripheral populations of other subspecies (Table 2). For westslope cutthroat trout, all remaining peripheral conservation populations are disjunct, and 21/43 (49%) of these met persistence criteria. Fifty percent of remaining continuous peripheral populations of Colorado River cutthroat trout were considered to be persistent, but less than 2/14 (14%) of disjunct populations were. All disjunct peripheral populations of Rio Grande cutthroat trout have been extirpated. Of 8 remaining continuous peripheral Rio Grande cutthroat trout populations, only 2 (25%) were considered persistent. Historically, Bonneville cutthroat trout had no continuous peripheral populations. Of remaining disjunct peripheral populations, only 5/39 (13%) were characterized as persistent, and these populations occupy an average of less than 13 km of stream habitat. The disjunct peripheral populations that were not considered persistent averaged only 4 km of occupied habitat.

Discussion

The conservation value of an individual population is generally gauged in the context of a species’ abundance, and its genetic, ecological, and life history diversity range-wide (e.g., Gustafson et al. 2007). Without full knowledge of these characteristics across all populations, however, alternative means are needed for evaluating conservation priorities. Identifying peripheral populations may be a useful approach for assigning conservation values because of their assumed contribution to within-species biodiversity, arising from often unique evolutionary histories and the potential for distinct future evolutionary trajectories (Lesica and Allendorf 1995; Taylor et al. 2003). Assessing conservation needs relative

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**Figure 7.** Historical distribution of core and peripheral populations of Yellowstone cutthroat trout.
to range distributions in fishes is especially difficult because peripheral populations of fishes have received relatively little attention in the scientific literature. In a recent review, Hampe and Petit (2005) found that only 4% of studies on peripheral populations were focused on aquatic systems, and we know of no studies that have attempted explicitly to define peripheral populations (sensu Schwartz et al. 2003; Channell and Lomolino 2000a, b) in trout. Identification of peripheral populations using geography, as done herein, can serve as a useful first step to characterizing potential historical within-subspecies diversity and understanding what may have already been lost, to guide future conservation needs (e.g., Gustafson et al. 2007).

In general, inland cutthroat trout are characterized by high among-population genetic diversity (Loudenslager and Gall 1980; Allendorf and Leary 1988; Neville et al. 2006; Peacock and Kirchoff 2007). This differentiation may be magnified in peripheral populations with distinct population dynamics (e.g., population fluctuations and/or bottlenecks) and colonization histories (Hedrick 1999; Nielsen 1999; Taylor et al. 2003), emphasizing their potential for disproportionate contributions to within-species biodiversity. In our study, the majority of peripheral populations have already been lost, and many of those remaining have a low likelihood of persistence because of small population sizes and limited habitat extents, due primarily to habitat degradation and fragmentation (Horan et al. 2000). Particularly in light of rapid environmental change, remaining peripheral populations may merit special focus to conserve potentially unique genetic characteristics and/or adaptations such as higher temperature tolerance (Nielsen 1999; Taylor et al. 2003; Flebbe et al. 2006; Rieman et al. 2007; Beatty et al. 2008) and for consideration for introduction efforts in the event that current habitats are eliminated.

The spatial patterns associated with peripheral populations and their losses differ even among subspecies of cutthroat trout and will need to be evaluated on a subspecies-by-subspecies basis. The cutthroat trout subspecies we evaluated had vary-

Figure 8. Current distribution of core and peripheral populations of Yellowstone cutthroat trout. Note that some populations (shown by dotted lines) have been introduced into previously unoccupied stream segments but still within their historical range.
Figure 9. Historical distribution of core and peripheral populations of Rio Grande cutthroat trout.
Figure 10. Current distribution of core and peripheral populations of Rio Grande cutthroat trout. Note that some populations (shown by dotted lines) have been introduced into previously unoccupied stream segments but still within their historical range.
ing patterns in terms of the proportion, geographic distribution, and magnitude of extirpation of peripheral populations related to latitude and hydrologic boundaries, but peripheral populations of all subspecies had high magnitudes of decline relative to core populations. Bonneville, Colorado, and Rio Grande cutthroat trout historical distributions extended south to warmer latitudes where suitable habitats are primarily associated with isolated mountain ranges that were occupied by disjunct peripheral populations. Most of these have now been extirpated or have low likelihood of persistence. In contrast, the westslope and Yellowstone cutthroat trout have the northern-most ranges and tended to have peripheral populations on the eastern and western extent of their distribution, because their distributions centered on core areas of the Rocky Mountains and are naturally constrained to the south by drainage basin boundaries. Likewise, patterns of loss were also not consistent geographically; westslope and Yellowstone cutthroat trout ranges have contracted to the center of their distribution, Bonneville and Rio Grande cutthroat trout distributions are contracting to the north, and the Colorado River cutthroat trout distribution is contracting to the north and the higher elevations of the Colorado River Basin. These contrasting spatial patterns among subspecies (sensu Sagarin and Gaines 2002) suggest that simple rules for classifying peripheral populations and identifying patterns of population loss based solely on range margins do not apply here, and that core-peripheral population designations and associated inferences about conservation value need to be considered on a case-by-case basis. However, despite spatial differences among subspecies, the magnitude of loss of peripheral populations across all subspecies is noteworthy.

Our results regarding losses of peripheral populations are clearly dependent on our approach to defining peripheral versus core populations. The aquatic systems on which we focus have different attributes from the more commonly-referenced terrestrial systems in that physical connectivity and opportunities for dispersal among populations are constrained by river systems, which originate in high-elevation mountain ranges and can drain towards or away from the center of the range. This makes defining the “core” and “periphery” complex, and not necessarily related to the geographic center or edge of the range. We based our definition on hydrologic and topographic connectivity in the hopes of maximizing the likelihood that the regions we defined as core versus periph-

Figure 11. Historical distribution of core and peripheral populations of westslope cutthroat trout.
eral historically supported trout populations with different dispersal patterns and levels of population connectivity. Intuitively, populations occupying isolated stream networks that infiltrate completely into historical lake beds (e.g., West Desert Bonneville cutthroat populations; Figure 13) are easily classified as disjunct peripheral populations. Classifying continuous peripheral populations can be more tenuous, but these populations may still have different ecological and genetic characteristics than truly core populations (Bunnell et al. 2004). Factors such as elevation (Angers et al. 1999), habitat heterogeneity (Fausch et al. 2002), and natural barriers (Costello et al. 2003; Taylor et al. 2003; Wofford et al. 2005; Neville et al. 2006) can also isolate and differentiate trout populations even within what we consider to be core habitats.

Similarly, our criteria for persistence were necessarily coarse due to the nature of available data, and in some cases may not capture the true probability of persistence in terms of the complicated demographic, genetic, and environmental factors that promote or reduce persistence (e.g., Hilderbrand and Kershner 2000). Therefore, in many cases our estimates of persistence may be optimistic. It is important to note well that prioritizing peripheral populations for conservation is not without controversy, and often in the related literature the attributes of peripheral populations are broadly assumed but empirically untested. For instance, some have argued that the reduced abundance, and therefore greater extirpation risk, of these populations means they should not be considered as viable components of biodiversity because scarce resources may be wasted on trying to conserve them (see discussion in Bunnell et al. 2004 and Hampe and Petit 2005). Yet peripheral populations do not always show reduced abundances (see Sagarin and Gaines 2002; Sagarin et al. 2006) and many peripheral populations have persisted through major climatic shifts, founder events, and extreme selective pressures, and in this sense have already withstood the test of time and demonstrated remarkable long-term viability (Nielsen 1999; Bunnell et al. 2004; Hampe and Petit 2005; Antunes et al. 2006). The somewhat opposing theoretical expectations regarding the genetic characteristics of these populations also make it difficult to assign conservation value consistently. From one perspective, the assumed attributes of populations in peripheral, marginal habitats (small, fragmented, unstable, swamped by gene flow from the core) are thought to constrain their abil-

Figure 12. Current distribution of core and peripheral populations of westslope cutthroat trout.
ity to adapt to local environments – possibly a primary reason why range limits exist where there are no barriers to dispersal (Kirkpatrick and Barton 1997; Kawecki 2008). At the same time, others argue that the frequent population bottlenecks and founder events experienced by small fragmented populations at the edge of species’ ranges can set the stage for the fixation of beneficial alleles and genetic reorganization events that would be unlikely in larger, more stable populations experiencing weaker selection pressures (Lesica and Allendorf 1995; Nielsen et al. 2001).

As with many things in ecology, it is likely that the evolutionary and conservation value of peripheral populations is partially context-dependent (sensu Stockwell et al. 2003), and population-specific information such as abundance, ecological uniqueness, genetic characteristics, and levels of migration should be evaluated before making conservation and management decisions for these populations. However, both theory and empirical data would suggest these populations should be characterized by high levels of among-population differentiation and potentially unique genetic variants, and therefore collectively represent a disproportionate amount of within-subspecies diversity. The oft-cited tenet of conservation “save all the pieces” (Leopold 1949) would argue for careful consideration of their conservation value, particularly in light of an uncertain future where maintaining diversity and adaptive potential will be critical for long-term viability. We hope that our geographical characterization of peripheral populations and their losses will emphasize the need for closer evaluation of conservation priorities for peripheral populations in inland cutthroat trout and other fishes.

**Management implications**

Our study indicates that additional management actions may need to be directed towards peripheral native trout populations. Of course, the results of broad-scale assessments, including ours, should be augmented with finer-scale stream and population data to inform management decisions, but our results may be useful in identifying those populations that are in greatest need of management attention. For example, peripheral populations that fall far below persistence thresholds and/or are in high-risk areas for climate change-driven disturbance (Rieman et al. 2007; Williams et al. 2009) should receive initial attention. Declines of remaining peripheral populations are not likely to be consistent across all river basins or geographic areas. Yet to maximize within-species biodiversity, it is important to conserve at least some minimum number of populations across all river basins. Rieman et al. (2007) recommended that five populations meeting persistence thresholds be maintained in each subbasin (4th Code Hydrologic Unit) for long-term conservation of bull trout. Because of natural limitations on available habitat in some of the more arid regions occupied by peripheral populations, this goal may not be realistic or even possible in areas such as the West Desert for Bonneville cutthroat trout, or the San Juan Basin for Colorado River cutthroat trout. In these instances, it is advisable to maintain as many populations as possible given restrictions on available habitat. Even if habitat cannot be expanded, restoring the quality and extent of riparian zones and thermal refugia may help buffer stream systems from disturbance and on-going impacts of climate change (Seavy et al. 2009). In general, larger populations and those in higher quality and more heterogeneous stream systems are more likely to survive prolonged drought, flooding, or wildfire in their watersheds (Dunham et al. 2002, 2003; Neville et al. 2009).

More frequent monitoring will aid in the conservation of peripheral populations (Dauwalter et al. 2009). Because of their small geographic extent, many peripheral populations are vulnerable to disturbance, including relatively small increases in stressors. Frequent monitoring can help with the early detection of detrimental physical or biological changes. Although usually somewhat isolated and removed from hydrologic connections that would facilitate non-native species invasion, if introduction does occur in peripheral habitats, a non-native species could quickly spread through the system, and there is growing concern that such invasions may be facilitated by climate change (Fausch 2008). Initial

<table>
<thead>
<tr>
<th>Cutthroat subspecies</th>
<th>Peripheral classification</th>
<th>Persistent populations</th>
<th>Non-persistent populations</th>
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<tr>
<td></td>
<td></td>
<td>Number of populations</td>
<td>Stream habitat (km)</td>
</tr>
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<td>5</td>
<td>62</td>
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</tr>
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genetic assessments are needed for many peripheral populations to understand their genetic distinctiveness, “health,” and conservation needs (Dunham et al. 1999). If collected over time, genetic data can be an efficient and effective way to monitor changes in factors such as effective population size, inbreeding, or hybridization (Schwartz et al. 2006).

Translocations of native trout from peripheral populations into new or former habitat could provide conservation benefits, but are often unsuccessful (Harig and Fausch 2002) and are not without risk. Translocating fish into novel habitat spreads the risk of extinction for that species, and may put other species at risk (Ricciardi and Simberloff 2009) and establish a new evolutionary trajectory for the translocated population when compared to the original donor populations (Stockwell and Leberg 2002; Stockwell et al. 2003). Differential selection and founder effects are common when establishing new populations from a small number of individuals (Wilcox and Martin 2006; Yamamoto et al. 2006). These risks can be minimized if translocations are repeated over time (if not detrimental to the source population) and if fish are moved between similar habitats within their historical range. In general, translocations should only occur between habitats in the same river basin or geographic area. In some instances, a lack of sufficient available habitat within the same river basin or geographic area may make translocations problematic: Harig and Fausch (2002) found that a minimum watershed area of 14.7 km² is likely needed for a successful translocation, and Hilderbrand and Kershner’s (2000) minimum stream habitat threshold of 9.3 km for long-term persistence is another useful guideline for gauging necessary amounts of habitat for cutthroat trout. Meeting population size criteria for long-term population persistence may be difficult and managers should not underestimate risks associated with small population sizes (Traill et al. 2009).

Conservation of peripheral populations will help preserve remaining genetic, life history, and evolutionary diversity within native trout. Retaining within-species biodiversity to allow for adaptation to fringe areas, small habitats, and harsh conditions should provide a substantial evolutionary advantage during periods of rapid environmental change, which are likely to characterize the future of coldwater fishes.

Figure 13. Peripheral populations of Bonneville cutthroat trout persist in small streams draining Utah’s Deep Creek Mountains along the western edge of the subspecies’ range. (Photos: Warren Colyer and Amy Harig)
Acknowledgments

The authors thank the Bonneville Cutthroat Trout Working Group for providing updated 2009 population status information for that subspecies. We would also like to thank Gary Garrett of the Texas Parks and Wildlife Department for assisting with mapping the historical distribution of Rio Grande cutthroat trout in Texas. Matt Mayfield and Sabrina Beus kindly prepared the figures. We also appreciate reviews of the manuscript by Jeff Kershner, Craig Stockwell, Justin Fisher, Sujan Henkanaththegedara, Brandon Kowalsk, David Mushet, Kevin Purcell, Patricia Flebbe, and an anonymous reviewer.

References


Background

Even back more than 100 years ago there were those rare individuals who expressed concern about possible extinctions! It seems fitting that California, often referred to as the Golden State, should have as its state fish the magnificent golden trout, *Oncorhynchus mykiss aguabonita*. Originally described in 1892 by ichthyologist and Stanford University President David Starr Jordan, the golden trout—and their fragility throughout their native waters in the upper Kern River drainage—were noted early in their history and were among the first fishes for which conservation measures were proposed. Stewart Edward White (1904) brought the matter to the attention of his friend President Theodore Roosevelt, noting the relative ease with which trout could be caught by anglers and presumably brought to extinction. In his 1904 novel *The Mountains*, White wrote of the problems faced by the golden trout on California’s Kern Plateau.

Roosevelt shared White’s concern and, through U.S. Fish Commissioner George M. Bowers, dispatched biologist Barton Warren Evermann of the U.S. Bureau of Fisheries to make a field assessment of the situation. Evermann began his major study of the area in 1904, and published in 1906 (Evermann 1906) his classic paper: “The Golden Trout of the Southern High Sierras.” Suggested management principles (artificial propagation, bag limits, etc.) are still in use today by the California Department of Fish and Game. Evermann saw what molecular geneticists later confirmed, and described four forms of this native fish, aligning them morphologically with the areas from which they were collected: *Salmo roosevelti* from Golden Trout (Volcano) Creek, *Salmo aguabonita* from nearby South Fork of the Kern River, *Salmo whitei* (named in recognition of Stewart Edward White) from the Little Kern River, and *Salmo gilberti*, the Kern River rainbow from which the other forms no doubt evolved following isolation by major volcanic eruptions and topographic change in that area thousands of years ago. More recent taxonomic studies now place salmonids within this group under...
the genus *Oncorhynchus*, rather than *Salmo* (Stearley and Smith 1993).

**The physical situation**

In order to fully comprehend the magnitude of fishery recovery efforts, the reader must be aware of the physical circumstance and location of the golden trout native range. California’s Sierra Nevada extends for about 643 km (400 miles), essentially from north to south, along the eastern portion of the state. The Kern Plateau, home of the golden trout, lies at the extreme southern end of this range, just south of Mount Whitney, the highest peak in the contiguous 48 states at 4,418 m (14,496′) elevation. From Mount Whitney the Sierra gradually tapers off to the south. Golden trout country ranges from about 3,353 m (11,000′) to 2,438 m (8,000′) in its lower areas and now is encompassed primarily within the Golden Trout Wilderness of the Inyo National Forest. The Kern River and its tributaries drain southward and westerly off the Sierra, historically flowing into nearby Tulare Lake and in extremely wet years northerly through California’s Central Valley and into the Pacific Ocean. In its lower reaches today, most of the Kern River is diverted for irrigation into Central Valley farms.

Access to the golden trout country today is very difficult. Road access simply does not exist, and to reach the area involves about a 4–5 hour hike or horseback trip from the eastern Sierra over 3,353 m (11,000′) passes, or via an equally lengthy journey from the south. Until the early 1980s, when provisions of the newly created Golden Trout Wilderness were implemented, access to the area was possible via the 487 m (1,600′) Tunnel Meadows airstrip, lying at an elevation of 2,743 m (9,000′) that could accommodate a Cesna 206 aircraft with the ability to transport personnel and fish restoration equipment (e.g. 208 L [55-gallon] drums, nets, chemicals, live cages, electrofishing gear, batteries, and other heavy equipment). In later years this type of backcountry work was necessarily relegated to packstock. In earlier years, fish could be restocked by helicopter. Under wilderness regulations, packstock now remain our only alternative for distribution.

**The initial problem**

Sometime during the mid-1900s an invasion of brown trout (*Salmo trutta*) and an equally insidious golden trout × rainbow trout hybrid into the South Fork Kern River, unbeknownst to us, was rapidly eradicating and contaminating golden trout within much of its evolutionary area. When I first learned of this in 1969, I noted in some areas of the South Fork Kern River that brown trout outnumbered golden trout by nearly 100 to 1. These goldens were rapidly approaching extinction and, without our intervention, would soon have become extinct.

**The remedy**

Thus began a major nonnative trout removal project, started in 1969 and still in progress today. It involves exclusion of further nonnative downstream trout introductions (the source of much of the problem), chemical treatments to remove invading fishes, fish barrier construction to prevent reinvasion, and post-treatment reintroduction of hopefully pure golden trout stocks. There seems little question that what I am describing constitutes perhaps the most involved and lengthy effort ever conducted for the restoration of any fish species, freshwater or marine, compounded by habitat damage resulting from a century of livestock overgrazing. There are no quick or easy answers to such a situation. The overall project involved chemical treatment of more than 160 km (100 miles) of stream, and through the years required...
on-the-ground assistance from more than 100 persons representing the California Department of Fish and Game, U.S. Forest Service, U.S. Fish and Wildlife Service, Nevada Department of Wildlife, and the University of California. Inyo National Forest managers are now working to reduce, or eliminate, the livestock problem.

To achieve project objectives, chemical treatments to remove brown trout and hybridized golden trout × rainbow trout were conducted during a period extending for 25 years, from 1969 to 1994, initially utilizing calcium hypochlorite (HTH), then antimycin, rotenone, and combinations of the latter two. Antimycin was a relatively new chemical in 1976 when it was first used by us, and we were anxious to learn more about its overall environmental impact, especially on highly important aquatic insect fauna. We therefore implemented a major study conducted by Sally Stefferud, then a graduate student from Oregon State University and an employee of the California Department of Fish and Game, and now recently retired from the U.S. Fish and Wildlife Service. We were fortunate in this case to have within 182 m (200 yards) of the South Fork Kern River, the totally separate drainage of Golden Trout Creek, separated by late Pleistocene vulcanism and glaciation, from which winged insect forms could quickly re-colonize treated areas of the South Fork Kern, and where golden trout were held for restocking following piscicide application. Utilizing a triage concept, which considered the fact that without chemical treatment extinction of the golden trout was a virtual certainty, and the loss of any aquatic insect taxa highly unlikely, we felt it safe to continue with the project. Both rotenone and antimycin strongly affect all gill-breathing organisms.

A related dilemma

To meet golden trout management needs, in 1917 the California Department of Fish and Game established egg-taking facilities at the nearby Cottonwood Lakes, near headwaters of the South Fork Kern yet hydrologically separated. In 1891 the Cottonwood Lakes had been stocked with golden trout from Cottonwood Creek originating from Volcano Creek. Rainbow trout inadvertently introduced during the 1930s may have been the source of genetic hybridization with the Cottonwood Lakes broodstock (University of Montana fish geneticist Robb Leary, letter to E.P. Pister, 1995). Since 1917 Cottonwood Lakes golden trout eggs were hatched out at the Mt. Whitney Hatchery near Independence in the Owens Valley. The fingerlings produced were utilized for stocking waters throughout the Sierra Nevada and even exported to other states and nations.

Indeed, the Cottonwood Lakes fish began to show morphological aberrations typified by heavy spotting below the lateral line and were later verified by geneticists (Cordes, et al. 2003). California Fish and Game managers, faced with this situation, and a barn door closed long after the horse had escaped, still use this hybridized stock for fisheries management purposes. Most anglers are unaware of genetic integrity, and Cottonwood Lakes fish remain physically very attractive. This entire matter continues under close scrutiny and scientific discussion. I began to suspect this introgression as early as 1953 at the beginning of my long career working to restore native fishes throughout California and the Southwest. The Department of Fish and Game is now investigating ways to establish a new, uncontaminated broodstock, and this will also require major input from geneticists.

Where are we now?

At this point (41 years after the first treatment) we now appear to have been successful in removing brown trout and even less acceptable hybrids from the upper South Fork Kern River. If our fish barriers remain intact the status quo should continue, assuming that illegal introductions above the barriers do not occur (Rahel 2004). Barriers
were placed to require future chemical treatment only of the lowest stream sections, precluding treatment of the entire drainage above. Management actions to restore and protect the California golden trout now rely largely on guidance from geneticists who we hope can tell us what we need to know about the purity and diversity of existing populations, both in the South Fork Kern and in nearby Golden Trout Creek. As Bob Behnke once stated (with his usual combination of humor and pragmatism): “I keep a bottle of whiskey under my desk, just awaiting the next phone call from a fish geneticist.”

There is a growing need among the larger public and angling communities for an improved environmental ethic that emphasizes the overwhelming importance of native species as opposed to nonnatives, as well as the need to monitor these populations to detect change (including spread of nonnatives). The need for monitoring will become even more important as climate change progresses. The role of public education in preservation of species cannot be overemphasized.

The future

A wise person once observed that understanding a problem constitutes at least half of its solution. I remain optimistic about the future of the golden trout. We are now much farther ahead than we were in 1965 when the recovery effort started. I often draw the analogy of a person painting his house with a toothbrush. When you finally realize the difficulty involved, you’ve gone so far that you know you have to keep going. I remain involved today even at the age of 81, and 21 years into retirement. Despite the fact that the golden trout project has been assumed by highly competent successors, after being involved with it for more than 50 years and convinced that history of this sort remains very important, I find it difficult to completely “let go.”

Recognizing that we still have a lot to do before we totally understand and solve the myriad problems involved with such an extensive recovery effort, the California Department of Fish and Game and other cooperating agencies provide a road map into the future with their “Conservation Assessment and Strategy for the California Golden Trout (Onchorhynchus mykiss aquabonita) Tulare County, California” (California Department of Fish and Game 2004). This document provides a detailed history of past recovery work and a strategy for future action. Easy answers? There are none. Hard work? More than one can imagine.

References


Product stewardship is a concept where environmental protection centers on the prudent use of the product, and everyone involved in the use of the product, is asked to take responsibility for reducing its environmental impact. This concept is a natural fit for the piscicides rotenone and antimycin, since their use is often controversial because of environmental and public health concerns. Those not practicing stewardship often end up dealing with time-consuming public relations and environmental regulatory problems (see Fisheries 25(5):22-23; 27(6):10-18; 30(4):29-31; 30(5):10-19; 35(2):61-71). Since the 1980s, their use has been challenged, halted, and discouraged in many areas of North America. In 1993, following AFS symposia on fishery chemicals, the need to respond to these concerns and issues and develop stewardship programs was recognized, and the Fish Management Chemicals Subcommittee (FMCS) was organized under the Task Force on Fishery Chemicals. The goals of the FMCS are to provide (1) leadership in the learning and training of practicing fishery professionals on the safe, effective and prudent use of piscicides and (2) stewardship of piscicides in attaining overall ecosystem balance. These goals are complementary to those of the AFS Strategic Plan of becoming a leader in the conservation of fisheries resources and facilitating learning and training for practicing professionals.

Rotenone and antimycin have been used by fishery managers to remove “undesirable” fish from lakes and streams for more than 50 years, although the definition of “undesirable” has changed considerably with shifting conservation values and understanding of ecosystem function. Previously, piscicides were used almost exclusively for creating and maintaining fisheries comprised of game species, sometimes at the expense of native species. Now the focus has begun to reverse, and more common objectives today are restoring native species, eliminating invasive alien species, and maintaining natural biodiversity in native ecosystems. Nobody would have thought of the idea of using rotenone to remove nonnative game fish for the restoration of native amphibians 40 years ago, although the Lawrence Livermore National Laboratory in California did just that in 2006.

In 1997, the FMCS obtained the first of several grants for rotenone stewardship from the U.S. Fish and Wildlife Service (FWS), Division of Federal Aid to determine current use patterns, issues and restrictions, and to use this information in the development of a technical and administrative guidelines manual, the Rotenone Use Manual. Following the symposium entitled “Rotenone in fisheries management: are the rewards worth the risk?” at the 2000 annual AFS meeting, the “Rotenone Stewardship Program” was established. The objectives of the Rotenone Stewardship Program are to assure the safe, effective and prudent use of rotenone by fishery professionals, inform the public of rotenone’s benefits and risks, provide up-to-date information to fishery professionals on all aspects of rotenone use, and develop proactive strategies for rotenone’s continued use. Over the years, the FMCS has been involved in many aspects of rotenone use from native fish restoration, including the development of piscicide information for the general public, addressing public health and environmental concerns, and most recently providing input to the development of water quality discharge permits. Much of this information has been published in professional journals and magazines and is available on the Rotenone Stewardship Program website at www.fisheries.org/units/rotenone.

In 2000, FMCS obtained administrative funds from the FWS Wallop-Breaux Sports Fish Restoration Program to assess the current and potential use of antimycin in fisheries and its potential for reregistration (see Fisheries 27(6):10-18). Although not used as extensively as rotenone,
it was used by the catfish farmers for scaled fish control and by some fish and wildlife management agencies for the restoration of native species. During the assessment, several issues were identified including the lack of adequate instructions on the product labeling. To correct this void, the FMCS wrote the Fintrol® Stream and River Use Monograph and the Fintrol® Pond, Lake and Reservoir Use Monograph; both can be downloaded from the AFS website at www.fisheries.org.

In 1988, the U.S. Environmental Protection Agency (EPA) placed all pesticides including rotenone and antimycin registered prior to 1984 into a reregistration process. The process required acute and chronic toxicity and environmental fate and behavior data to support the generation of assessments to estimate risks on human health and the environment. Fortunately, the FWS had funded many of the needed studies for rotenone in the 1980s so these data were available. However, similar data were not available for antimycin, but the FMCS 2000 assessment of antimycin use (see Fisheries 27(6):10-18) convinced the EPA that some of these studies were not necessary at the present time for the reregistration to proceed. FMCS kept fisheries professionals informed on the progress of the reregistrations in several updates published in Fisheries in 2007 and 2008. After the EPA issued the Reregistration Eligibility Decision (RED) in March 2007 (EPA-738-R-07-005) authorizing the reregistration of rotenone, FMCS provided written comments to the EPA on proposed risk mitigation measures and labeling changes, and many state and federal fish and wildlife agencies followed suit by providing similar comments to the EPA. Significant concerns included enforceability and content of operation manuals versus labels, need for additional safety gear, allowable treatment rates and sites, chemical deactivation, and restrictive application procedures. FMCS proposed alternative risk measures to the EPA at an August 2008 meeting that were practical, and limited rotenone exposure; these were ultimately accepted by the EPA. There were similar issues with antimycin, and the FMCS provided similar comments to the EPA after they issued the antimycin RED in May 2007 (EPA-738-R-07-007). As a requirement for the reregistration for rotenone, FMCS developed the AFS Rotenone Standard Operating Procedures (SOP) Manual. This was written in conjunction with the EPA and rotenone registrants using FWS funding.

In 2001, FMCS began discussing the need for training professionals in piscicide use, and in 2003, in cooperation with FWS, developed a training course with the intent that the training would standardize techniques for the application of piscicides using the Rotenone Use Manual, and more recently, the Rotenone SOP Manual as guides. FMCS, in conjunction with Utah State University (USU) and AFS USU Student Subunit of the Bonneville Chapter, offer a week-long training course on piscicides entitled “Planning and Executing Successful Rotenone and Antimycin Projects.” The course focuses on soliciting public involvement, project planning, environmental and applicator safety, and application and deactivation techniques. The course has also been given in other locations including Arizona, and the course is also planned for New York in in 2011. The tenth class was given in 2010, and over 150 fishery professionals have been trained to date. EPA's REDs for rotenone and antimycin recommend that applicators receive training on the use of piscicides. A schedule of current AFS classes can be viewed at www.fisheries.org/units/rotenone.

A number of issues have developed over the years including adequate training and guidance for applicators, public education in an era of public concern, unscientific assessment of impacts, indiscriminate acceptance of non-chemical alternatives, duplicative and often counterproductive environmental regulations, and difficult acceptance of environmental tradeoffs. To facilitate better communication among fishery professionals on these issues, FMCS sponsored three symposia at AFS national meetings: (1) The Role of Environmental Stewardship in Shaping the Use of Fishery Management Chemicals (2002); (2) National and International Challenges and Lessons Learned on Fish Management Chemicals (2005); and (3) Global Issues and Policies Affecting Ecosystem Restoration Projects using Rotenone and Antimycin (2007).

In 2009, the Sixth Circuit Court mandated that the EPA develop wastewater discharge (National Pollution Discharge Elimination System (NPDES)) permits for the application of piscicides in and around water. The proposed permit conditions were distributed this year, and NPDES permit conditions will be finalized in 2011. This may prove to be the most challenging task yet for the use of piscicides: crafting NPDES permit conditions that do not require inappropriately low treatment dosages nor restrict the size of the treatment zone areas in an attempt to “minimize pesticide discharges into waters. If target fish survive and reproduce and ultimately repopulate the treatment area after treatment, then a considerable quantity of piscicide as well as time and expense would be wasted. Such potentially counterproductive restrictions have already been permitted in Vermont and California by water quality agencies. There were also significant process, legal, and jurisdiction issues associated with the proposed NPDES permits, too extensive to discuss here.

The use of piscicides will continue to be challenged on a number of fronts despite our best efforts at stewardship. These issues will be the focus of the next FMCS symposium on piscicides at the 2011 AFS Annual Meeting in Seattle.
Southern New England Chapter

The Southern New England Chapter’s 2010 winter meeting was held at the University of Connecticut’s Avery point campus in Groton, CT on 28 January. There were 104 attendees, including 33 students. The meeting’s technical presentations included thirteen oral papers and nine posters. In keeping with the Chapter’s interest in fostering student participation, fourteen of these presentations were made by students. Abstracts may be found on the Chapter’s website at www.snec-fisheries.org.

One award was presented at the meeting. Carrie Byron of the University of Rhode Island received the Saul B. SAILA Best Student Paper Award for her presentation at the June 2009 Chapter meeting on the feeding ecology of four demersal predators: black sea bass, scup, northern searobin, and striped searobin.

—Donald J. Danila

Carrie Byron receives the Saul B. SAILA Best Student Paper Award from Karina Mrakovcich
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Heading north from 2009’s Nashville meeting, fisheries professionals, students, and guests gathered in Pittsburgh from 12 September to 16 September for the 140th Annual Meeting of the American Fisheries Society. The 2010 meeting theme was “Merging our Deeper Currents,” and conference goers met in the David L. Lawrence Convention Center. This, the world’s first “green” convention center, was a location in harmony with the planners’ desire to make AFS 2010 the “greenest” meeting to date.

On Friday, the Governing Board enjoyed a retreat and discussion time on the site of architectural marvel Fallingwater. Their deliberations continued Saturday at the Westin—the convention hotel—while other meetings and the off-site Basic/Intermediate GIS for Fisheries Biologists seminar took place elsewhere.

Sunday kicked off with a host of continuing education workshops and section meetings, with the much-anticipated Welcome Social beginning at 6 p.m. at the Convention Center. Attendees enjoyed fellowship, food, and
Monday morning opened with the Plenary Speakers Breakfast at the Convention Center. Plenary Session speaker Ian Cowx initiated the talks with “Fisheries and the Science Imperative.” Cowx, director of the University of Hull International Fisheries Institute (HIFI) in the United Kingdom, asked what the importance of fisheries was to society as he examined the shifting position and roles of science, people, and emerging environmental and sustainability issues in the management of fisheries. In a time when 55% of freshwater species are extinct, endangered, or threatened, he argues that fisheries ecologists are not asking the right questions. An imperative is the relationship between assessment (of management choices habitat managements) and resource management, along with a proper time interval for collection and monitoring of the data. The assessment processes and subsequent models also need to be accessible to everyone. Meanwhile, Cowx pointed out that another challenge for fisheries is their low standing from an economic perspective, in part because ecologists and economists are not operating in the same workshops or groups.

Following Cowx was Jane Lubchenco, who serves as administrator of the National Oceanic and Atmospheric Administration (NOAA). Her message entitled “Fisheries in the Current: The Role of Fisheries in the Nation’s New Ocean Policy” called this an exciting time in fisheries science, given President Obama’s probing questions during the BP Oil Spill. She explained how the IT revolutions in science have brought about a constant stream of data that requires careful examination, and she called for attendees to cross lines of age and disciplines to work on real world problems. In the area of international fisheries, there are huge challenges in regional management organizations because of unsustainable practices, and she argued that performance will increase when conservation and economics are aligned. Finally, Lubchenco highlighted the executive order signed in July, which established a National Ocean Policy by adopting the Ocean Policy Task Force. This document, which focuses on stewardship, assigns nine objectives to the newly-created National Ocean Council, and implements change in how 24 departments and offices think about how they operate.
laid out “What It Will Take to Save Wildlife on Earth.” He dedicated the talk to late mentor and Pennsylvania fish commissioner Ralph Abele who was known to say “Fight no small battles.” Schweiger encouraged attendees to move beyond the comfort zones of fisheries and take steps to improve the environment for the children who will inherit it. He highlighted example after example of the dangers and implications of the rising CO$_2$ in the atmosphere and argued that attendees had the obligation to keep the affected species alive. He discussed decline in trout habitats and Great Lakes ice cover. Like Lubchenco, Schweiger cautioned that discernment is needed for the barrage of environmental information and data. He mentioned the dangers of paradigm blindness in scientists, and encouraged attendees faced with environmental information to ask themselves who was speaking and why.

To conclude, Melissa Wuellner, assistant professor and distance education coordinator in the Department of Wildlife and Fisheries Science at South Dakota State University, spoke on “The Emerging Cohort of Fisheries Professional: Are We Really So Different from the Older Generations?” Wuellner discussed the membership crisis in scientific societies where young professionals and students do not make up enough of the membership populace to replace retiring Boomers. She mentioned helpful youth retention efforts, including dues reductions and increased service offerings; retention was also helped by the acquisition of new members during their student days through the influence of professors or other members. She argued that scientific societies must go beyond being just journals and meetings, and look for what young cohorts need to stay and succeed. She recommended more promotion of youth involvement, mentoring, the further development of networking, and journal review; and she suggested AFS applications, such as job placement assistance,
inexpensive web tools, and guidance during the transitions of students and young professionals. The Plenary Session was followed by the AFS Trade Show and Auction, an enjoyable time for attendees as they perused exhibits and posters, met with vendors, and enjoyed more food and drink. Numerous symposia were presented throughout the week, covering such sessions as freshwater ecology, new approaches to landscapes and fish-habitat relationships, and, probably most notable, the one pulled together by (now Past-President of AFS) Don Jackson, who invited government agencies to talk about their responses to the BP oil crisis (visit http://www.fisheries.org for transcripts and a web presentation, including the Q&As). In attendance were: Brian Alford of the Louisiana Department of Wildlife and Fisheries; Steve Murawski of the National Marine Fisheries Service (NOAA); Dan Ashe of U.S. Fish and Wildlife Service; and John Epifanio of the U.S. Geological Survey. Monday sessions began with

“Fish Culture,” “Invasive Species,” and “Conserving Aquatic Resources in the Ohio Basin: From Planning to Action.” To round off the day, there was a Student-Mentor Happy Hour.

Tuesday boasted continuing seminars from the day before, as well as new sessions dealing with “Stock Assessment Methods for Data Poor Situations,” “Sturgeon,” and other topics. The spotlight turned to students, and activities included a career fair, the terminal session for “Best Student Paper,” and a student-only Social aboard a boat from the Gateway Clipper fleet.

Also on Tuesday, the AFS Business Meeting was held. The Governing Board was represented well, both geographically and by discipline. All awards not presented at the Plenary Session were introduced (and will be published in our December issue). As well, there were two greetings from the international community: Felicity A. Huntingford, the President of the The Fisheries Society of the British Isles, and Shugo Watabe, who represented the Japanese Society of Fisheries Science.
A presentation was also given about next year’s meeting in Seattle. Executive Director of the AFS, Gus Rassam, gave the financial report. And the ceremony for new officers took place. Don Jackson retired to the position of Past President, with Wayne Hubert moving into his place as President. William Fisher became the President Elect. John Boreman became the First Vice President. And the Second Vice President, Robert Hughes, was ushered in.

Wednesday’s seminars included “Merging Deeper Currents — A Focus on Renewable Energy Development in Our Rivers,” and “Hydrokinetic Electricity Generation and Fish: Asking the Right Questions, Getting Useful Answers.” Wednesday evening’s Grand Social featured a field trip to the Pittsburgh Zoo and PPG Aquarium, a world leader in conservation and green initiatives. Attendees had use of the entire zoo, and visited the diverse wildlife, socialized, and enjoyed an ample food spread put on by the facility caterer “Taste of the Wild.”

On Thursday, attendees were able to enjoy the conclusions of multi-part seminars begun earlier in the week, as well as experience one-time presentations like “Science Perspectives on the British Petroleum Oil Spill in the Gulf of Mexico.” Thursday’s evening Farewell Social gave attendees a chance to relax on the Convention Center Terrace one last time.

AFS held its 120th meeting in Pittsburgh in 1990, and 20 years later for our 140th meeting, the location proved to be a great success. Next year AFS looks forward to heading to the west coast, where we’ll host our annual meeting in Seattle.

Additional photos from the meeting are available online at www.flickr.com/photos/americanfisheriessociety.
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.
It's already time to start planning your trip to Seattle for the AFS 141st Annual Meeting! The meeting's theme, “New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World,” promises to bring forth the latest and greatest information and discussions regarding the huge challenges facing fishery resource managers today. The AFS 2011 meeting will be 4-8 September 2011 at the Washington State Convention Center and neighboring Sheraton Hotel, in downtown Seattle. We look forward to seeing you in Seattle!

**General Information**

Aquatic resource professionals at all levels and backgrounds, especially students, are invited to submit symposia proposals and abstracts for papers in all relevant topics and disciplines. The scientific program of the meeting consists of three types of sessions:

- Symposia,
- Contributed Papers, and
- Posters.

Oral presentations except a limited number of symposium presentations, will be limited to 20 minutes (15 minutes for presentation plus 5 minutes for speaker introduction and questions). All oral presenters are expected to deliver PowerPoint presentations.

**Symposia**

The Program Committee invites proposals for symposia. Topics must be of general interest to AFS members, and topics related to the meeting theme will receive priority. Symposium organizers are responsible for recruiting presenters, soliciting their abstracts, and directing them to submit their abstracts and presentations through the AFS online submission forms. A symposium should include a minimum of 10 presentations and we encourage organizers to limit their requests to one-day symposia (about 20 oral presentations). Symposia with more than 20 presentations are strongly discouraged because of time constraints. The Program Committee will work with symposium organizers to fill unused time slots with appropriate presentations that were submitted as contributed papers.

Traditionally, symposia have been dominated by oral presentations and sometimes supplemented by posters. If posters are part of a symposium, they can be complemented by “Speed Presentations,” short oral presentations of the highlights of posters. This format elevates the profile of symposium posters, shortens the time required for symposia, and encourages interaction at the poster session. Speed presentations are an effective way to disseminate information and foster one-on-one interactions among symposium participants and poster presenters. See *Fisheries* 32(12):576 for more information on this format.

Regular oral presentations are limited to 20 minutes, but double time slots (i.e., 40 minutes) may be offered to keynote speakers. Symposium proposals must be submitted by 14 January 2011. All symposium proposal submissions must be made using the AFS online symposium proposal submission form, which is available on the AFS website (www.fisheries.org). If you do not receive confirmation that we have received your proposal by 21 January 2011, please contact the Symposium Subcommittee (see contact information below). The Program Committee will review all symposium proposals and notify organizers of acceptance or refusal by 11 February 2011. If accepted, organizers must submit a complete list of all confirmed presentations and titles by 4 March 2011. Symposia abstracts (in the same format as contributed abstracts; see below) are due by 11 March 2011.

**Format for Symposium Proposals**

(Submit using AFS online symposium submission form)

When submitting your abstract, include the following:

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

Confirmed: Yes/no

Format (regular or speed presentation):
1. _______________________________
2. _______________________________

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

CONTRIBUTED PAPERS AND POSTERS

The program committee invites abstracts for presentations for contributed paper and poster sessions. Authors must indicate their preferred presentation format:
1. Contributed paper only,
2. Poster only,
3. Contributed paper preferred, but poster acceptable.

Only one contributed paper presentation will be accepted for each senior author. We encourage poster submissions because of the limited time available for contributed papers. The program will include a dedicated poster session to encourage discussion between poster authors and attendees.

STUDENT PRESENTERS

Student presenters must indicate if they wish their abstract to be considered for competition for a best presentation (i.e., paper or poster, but not both) award. If they respond “no,” the presentation will be considered for inclusion in the Annual Meeting by the Program Committee, but will not receive further consideration by the Student Judging Committee. If students indicate “yes,” they will be required to submit an application to the Student Judging Committee. Components of the application will include an extended abstract and a check-off from their mentor indicating that the study is at a stage appropriate for consideration for an award.

ABSTRACT SUBMISSION

Abstracts for contributed papers and posters must be received by 11 February 2011. All submissions must be made using the AFS online abstract submission form, which is available on the AFS website (www.fisheries.org). When submitting your abstract:

- Provide a summary of your findings and restrict your abstract to 200 words.

All presenters will receive a prompt e-mail confirmation of their abstract submission and will be notified of acceptance and the designated time and place of their presentation by 15 April 2011.

The Program Committee will, as much as possible, group contributed papers thematically. To assist in this, you will have the opportunity during the abstract submission process to indicate which one or two of the following general topic areas best fit the concept of your abstract. Topics include:
- Bioengineering
- Communities and Ecosystems
- Contaminants and Toxicology
- Education
- Fish Culture
- Fish Health
- Fish Conservation
- Freshwater Fish Ecology
- Freshwater Fisheries Management
- Genetics
- Habitat and Water Quality
- Human Dimensions
- Marine Fish Ecology
- Marine Fisheries Management
- Native Fishes
- Physiology
- Policy
- Population Dynamics
- Statistics and Modeling
- Species-Specific (specify)
- Other (specify).

Late submissions will not be accepted. AFS does not waive registration fees for presenters at symposia, workshops, or contributed paper sessions. All presenters and meeting attendees must pay registration fees. Registration forms will be available on the AFS website (www.fisheries.org) in May 2011; register early for cost savings.

FORMAT FOR ABSTRACTS

For Symposium Abstracts (must be solicited by symposium organizer):

Enter Symposium title:
1. _______________________________
2. _______________________________

Specify format:
1. Oral
2. Speed presentation (accompanied by poster)

FOR CONTRIBUTED PAPER AND POSTER ABSTRACTS

Enter 2 choices for topic:
1. _______________________________
2. _______________________________

1. Contributed paper
2. Poster
3. Contributed paper preferred, but poster acceptable

FOR ALL ABSTRACTS, FORMAT AS IN THE FOLLOWING EXAMPLE

Title: An example abstract for the AFS 2010 Annual Meeting
Format: Oral
Authors:
Busack, Craig. NOAA Salmon Recovery Division, 1201 NE Lloyd Blvd., Suite 1100, Portland, OR 97232; 503/230-5412; craig.busack@noaa.gov
Ward, Dave. Columbia Basin Fish and Wildlife Authority, 851 SW Sixth Avenue, Suite 300 Portland, OR 97204; 503/274-7285; dave.ward@cbfwa.org

Presenter: Craig Busack
Abstract: Abstracts are used by the Program Committee to evaluate and select papers for inclusion in the scientific and technical sessions of the 2010 AFS Annual Meeting. An informative abstract contains a statement of the problem and its significance, study objectives, principal findings and application, and it conforms to the prescribed format. An abstract must be no more than 200 words in length.

Student presenter? No

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They don’t have courses with fish or fisheries in the title anymore.

**Well, what kind of courses did you take that involved fish or water?**
The tech perked up and responded with a short list.

> When I was an undergrad, I had Evolution and Taxonomy of Lower Vertebrates, Environmental Biology, and Limnology.

**Did you go out in the field with any of those courses?**
Yep. We had three field trips in Limnology, one to a lake, another to a reservoir, and a third to a sewage lagoon. The TA demonstrated how to sample water quality parameters at each place.

**What did you take for your master’s?**
I had stream Ecology, Landscape Ecology, Animal Behavior, Natural Resource Management, and Conservation Biology, along with a couple GIS courses, three stats courses, and one on conflict resolution.

**What’d you do for your thesis?**
I modeled possible effects of climate change on native fish distributions in the state.

The district biologist draws in a deep breath, lets it partially out, and says,

**Son, I think we have a problem.**

While this is just a story, it reflects the beliefs and maybe the experiences of many fisheries biologists working in the field for state and federal agencies. The education that students are receiving at universities may not be matching the needs of agencies focused on traditional sport or commercial fisheries management activities. Is this a problem or not?

In a first step toward addressing this issue, the AFS Governing Board held a retreat on 10 September, 2010 preceding the annual meeting in Pittsburgh. Six fisheries scientists from agencies and universities provided their perspectives. Ron Essig, a biologist with the U.S. Fish and Wildlife Service, pointed out that the agency needs people with educations in habitat protection and restoration, population assessment skills, genetics, disease detection, and invasive species control, as well as with the ability to work with partners and stakeholders. John Boreman, recently retired from the National Marine Fisheries Service, described the needs in marine fisheries to be quantitative sciences (e.g., modeling, mathematics, and statistics), social sciences, resource management and policy, ecology, systematics, environmental impact analysis, toxicology, and pathology, with interdisciplinary abilities. Bob Curry represented state agencies and emphasized that they need management biologists, hatchery biologists, and research biologists, all with oral communication skills. Jesse Trushenski, a fish culture specialist and university professor, described how education in fish culture requires practical experience and how that is diminishing. She felt that “most recent grads have only learned how to grow fish on paper.” Mike Quist spoke about undergraduate education and illustrated changes in curricula over the last half century. Declines in field- and lab-based courses in the traditional “ologies,” sport or commercial fishes emphases, and practical experiences have occurred while there have been increases in ecology-focused courses steeped in theory with non-game, non-consumptive perspectives being emphasized. Steve Chips with the South Dakota Cooperative Fish and Wildlife Research Unit addressed graduate education. His perspective was that there is a changing demographic among students with a decline in the rural “hook and bullet crowd” and subsequent increases in students from urban areas with strong environmental and conservation interests. Faculty are changing in a similar manner as programs shift to accommodate sources of research grants that focus on ecological processes and generate more overhead.

Small group discussions among members of the Governing Board provided additional insights. One notion was that one of the strongest ways in which the AFS influences higher education is through its certification of professional fisheries scientists with schools maintaining curricula so graduating students may be certified.

There seemed to be consensus that education of fisheries scientists was a topic that needed to be addressed further and the Governing board provided a green light for this pursuit.

The AFS has joined with The Wildlife Society, The Society of American Foresters, and The Society for Range Management in the Coalition of Natural Resource Societies (CNRS). The executive directors of the four societies have reflected the concerns of their members regarding the training of future natural resource management professionals. They
are all asking, “Is there an impending crisis?” To determine if this is a valid question and to identify potential solutions if it is, the CNRS is organizing a topic oriented meeting on the subject sometime in 2011. Planning is underway to include representatives from agencies, higher education, and nongovernment organization in the discourse. Watch for future announcements on this meeting. It should be a “humdinger” providing better insight into the issue and identifying how the Society may lead the way in a changing world.

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**CALENDAR:**

To submit upcoming events for inclusion on the AFS Web site Calendar, send event name, dates, city, state/province, web address, and contact information to cworth@fisheries.org. (If space is available, events will also be printed in *Fisheries* magazine.)

More events listed at www.fisheries.org.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
<th>City, State/Province</th>
<th>Web Address</th>
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<tbody>
<tr>
<td>Nov 7-12</td>
<td>Eastern Marine Biology of Fisheries Research Institute</td>
<td>Taitung, Taiwan</td>
<td><a href="http://www.tfrin.gov.tw">www.tfrin.gov.tw</a></td>
</tr>
<tr>
<td>Nov 11-14</td>
<td>Western Society of Naturalists Annual Meeting</td>
<td>San Diego, California</td>
<td><a href="http://www.wsn-online.org">www.wsn-online.org</a></td>
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<tr>
<td>Dec 10-13</td>
<td>Fifth Shanghai International Fisheries and Seafood Exposition—The Best Opportunity to Explore Chinese Market</td>
<td>Shanghai, China</td>
<td><a href="http://www.sifse.com">www.sifse.com</a></td>
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<tr>
<td>Dec 12-15</td>
<td>North Central Division, joint with Midwest Fish and Wildlife Conference</td>
<td>Minneapolis, Minnesota</td>
<td><a href="http://www.midwest2010.org">www.midwest2010.org</a></td>
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</table>
**Quantitative Ecologist/Data Analyst**


**Salary:** Depends on experience.

**Closing:** 1 December 2010.

**Responsibilities:** Work independently and with project scientists to develop and manage project-specific databases, facilitate quality control/quality assurance of these data, and perform statistical and spatial analysis.

**Qualifications:** M.S. in applied statistics or biostatistics, with supporting formal training in ecology, fisheries, and aquatic ecology; or a M.S. in ecology, fisheries, or aquatic ecology with supporting formal training in applied statistics and biostatistics, and a minimum of three years experience, preferably in quantitative ecology. Possess a demonstrated knowledge of analysis software, including but not limited to SAS, MATLAB, GIS and the application of this software to describe patterns in biological and environmental data and test hypotheses concerning these data.

**Contact:** Send cover letter and resume to HR@normandeau.

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**M.S. Graduate Assistantship**

University of Maine, Orono.

**Salary:** $19,500 per year, plus $2,400 health, tuition waiver. Funding for minimum of 2.5 years, teacher’s assistantship of up to 1 year, research assistantship of up to 1.5 years.

**Closing:** 1 November 2010.

**Responsibilities:** Model migration and survival of Atlantic salmon smolts in the Penobscot River. Work on collected data using acoustic and radio telemetry, as well as actively tagging and tracking fish.

**Qualifications:** B.S. in bio science or equivalent, excellent quantitative skills, and interest in fisheries. GPA of 3.0 and GRE of 1100. Interest in smolt physiology is an asset. Be motivated and quantitatively inclined

**Contact:** Send CV, transcripts, 3 references and GRE scores to USGS Maine Cooperative Unit, Attn J. Zyldlewski, 5755 Nutting Hall, University of Maine, Orono, Maine 04469. Contact- jzydlewski@usgs.gov.

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**Ph.D. Graduate Research Assistantship**

North Carolina State University, Raleigh.

**Salary:** $19,000 per year 12 months, health insurance and full tuition and fees paid.

**Start date:** August 2011.

**Responsibilities:** Project is focused on an across-scale survey of the causes and consequences of fish movement. This collaborative research project will be a mix of ecology, ecotoxicology, and fish biology, and will include field and laboratory components.

**Qualifications:** M.S. degree in biology, toxicology, fisheries, ecology, or related environmental science field. Exceptional students with a B.S. degree and appropriate experience will be considered. Experience in toxicology and/or analytical methods a plus, but not required. Admission is competitive. Selected students usually have GRE scores 1200 and a GPA 3.5, though exceptions can be made for students with specific skills and experience.

**Contact:** Please e-mail a letter of interest, CV, and unofficial copies of GRE scores, and college transcripts to Greg Cope, greg.cope@ncsu.edu. See: http://www.ncsu.edu/project/fish-lab.

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**M.S. Graduate Assistantships**

North Carolina State University, Raleigh.

**Salary:** Approximately $17,500 per year plus payment of health insurance, tuition, and fees.

**Start date:** August 2011.

**Responsibilities:** Available projects are focused on two issues: movement of coastal largemouth bass associated with habitat availability and hypoxia, and white bass life histories and movement patterns in inland reservoirs. Both projects are collaborative efforts with the North Carolina Wildlife Resources Commission and offer a mix of basic ecology and applied fisheries management.

**Qualifications:** Admission is competitive and successful applicants to our laboratory typically have GPA 3.5, GRE scores 1200, and at least some field or laboratory experience, though exceptions can be made. In addition, we are looking for students who are motivated, enthusiastic, and work well independently and in a large group.

**Contact:** E-mail a letter of interest, c.v., names of references, and copies of transcripts and GRE scores (official copies not necessary) to Derek Aday and Jim Rice at derek_aday@ncsu.edu and jim.rice@ncsu.edu. See http://www.ncsu.edu/project/fish-lab.

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**Associate Director**

New York Sea Grant Institute (NYSGI), College of Agriculture and Life Sciences, Cornell University, New York.

**Salary:** Depends on experience.

**Closing:** 19 January 2011.

**Responsibilities:** Lead a dynamic, highly-rated, university-based Sea Grant Extension program that addresses critical marine and Great Lakes coastal issues. Serve as a member of the senior management team engaged in administering, prioritizing, and expanding the NYSGI Program. Secure additional funding to complement the institute’s current $4M of support. Collaborate in establishing program direction and developing and maintaining contacts with academic units, key agencies, and legislative liaisons throughout New York State. Collaborate in formulating research and outreach priorities and directions. Collaborate in maintaining institute advisory mechanisms and groups. May serve as NYSGI liaison with specific agencies and programs. Serve as the assistant director for Cornell Cooperative Extension, providing leadership and

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**Extension, providing leadership and**

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**faculty members, hiring graduate assistants. If space is available, jobs may also be**

**printed in Fisheries magazine, free of additional charge.**
administration for Sea Grant Extension and coastal programs, supervising Sea Grant Marine and Great Lakes District program coordinators and other Sea Grant staff, and overseeing grant proposal development, submission, and reporting requirements. Develop, implement, and evaluate a substantive extension education program in her or his area of expertise that supports Sea Grant Extension Program priorities. Program may include relevant applied research and development of grant proposals to support the appointees extension and research activities. Program is a SUNY-Cornell partnership funded mainly by federal NOAA and New York State sources.

**Qualifications:** An earned Ph.D. with at least 5 years professional outreach and administrative experience in aquatic science, natural resource, or conservation management or other appropriate environmental sciences or a M.S. with 10 years programmatic and progressive administrative experience in the above fields and demonstrated leadership experience. Substantive professional experience in university-based outreach or non-formal education programs, as well as management or coordination of such programs.

**Program** is a SUNY-Cornell partnership funded mainly by federal NOAA and New York State sources.

**Contact:** To apply, send cover letter, resume, and transcripts to Nancy Greenawalt, New York Sea Grant, 112 Rice Hall, Cornell University, Ithaca, New York 14853. Review of applications begins 23 August 2010. For full position description see www.seagrant.sunysb.edu/article.asp ArticleID 357 or contact Nancy Greenawalt at nag3@cornell.edu or 607/255-2832. AA. EOE.
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- 96 page bibliography

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