Identify This Fish!

Unveiling the Recreational Giant

Twin Cities Meeting Wrap-Up

Managing for the Ecosystem or Economics?

Rethinking Research on Catch and Release Mortality
Know your octopus!

Octopuses are admirable creatures—they are intelligent, remarkably good at camouflage and predator avoidance, dexterous, and famously able to get in and out of a tight spot. The North Pacific Giant Octopus (**Enteroctopus dofleini**) is not targeted in Alaskan fisheries, but managers would like to limit octopus by-catch and develop fisheries. However, octopus are very difficult to tag, and 60 years of experiments have yielded little about their movement, abundance, and mortality. They can pull out external tags, disc tags and brands cause necrosis, and chemical tags quickly fade. A benign tagging method that provides long-term individual identification is essential for these population studies.

NMT’s Visible Implant Elastomer (VIE) Tags are meeting the challenge of providing individual and batch tagging for octopus. Liquid VIE is injected under the skin, but remains externally visible. Different colors and tag locations are combined to generate unique codes. VIE Tags are easy to use and can be applied across a wide range of octopus sizes. They have no negative effects on the octopus, and are retained at very high rates. In a 2 year mark-recapture experiment, University of Alaska researcher Reid Brewer and his team used VIE to tag over 1730 octopuses. They recaptured an impressive 14% of the released animals, of which a large proportion had been at liberty for at least 60 days and for as long as 374 days, demonstrating the effectiveness of VIE for long term studies (**Brewer, R. & B. Norcross. Fisheries Research** 134-136).

VIE is widely used from Alaska to Antarctica, and everywhere in between. Please contact us if we can help with your research.

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Top: Researcher Reid Brewer weighs an octopus during VIE tagging trials.
Bottom: VIE is injected under the skin, but remains externally visible, as in this octopus which was recaptured after 186 days. The code is read as: green—blue—blue—red—orange and identifies an individual octopus. Photos courtesy of R. Brewer.
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Cover: Image of Gyotaku print by Harry S. Schaeffer.
Is AFS Still Relevant?

John Boreman, President

In his opening remarks at the most recent American Fisheries Society (AFS) governing board retreat, “Re-imagining AFS,” President Bill Fisher noted that professional societies are currently experiencing many changes that are affecting their ability to serve members. Tighter budgets, more attractive alternatives, and changing expectations are leading to a greater demand by members for a return on their investment. Our society is no different. As with other professional societies, our society is facing a decline in membership, loss of revenue, and growing irrelevance to the younger (and even older) generations.

The stimulus for the theme of the retreat was a book entitled Race for Relevance: 5 Radical Changes for Associations (Coerver and Byers 2011). We were fortunate to have one of the book’s authors, Mary Byers, lead us through the six issues that professional societies are currently facing and five changes recommended by the authors to help societies survive. According to the book’s authors, the six issues facing today’s professional societies are (1) increased competition for the members’ time that can be devoted to society-related activities; (2) increased scrutiny by members into the return on their membership investment; (3) increased specialization and consolidation of professional societies; (4) generational differences in member values; (5) competition with for-profit associations; and (6) technological changes. These issues are impacting membership in professional societies that will require changes in operations and services. The five changes they propose in their book to address these issues are as follows: (1) overhauling the governance model and committee operations; (2) empowering the executive director and enhancing staff expertise; (3) thoroughly defining the membership market; (4) rationalizing programs and services; and (5) building a robust technology framework.

At the end of the morning’s discussion, the governing board decided to spend the remainder of the retreat discussing how AFS should move forward with the first four changes. The retreat attendees felt that the society was already on the path to building a robust technology framework. Dale Burkett, a former member of the governing board, facilitated the afternoon discussion.

The topic that received the most attention by the governing board members during the afternoon discussion was the challenge of overhauling the society’s governance structure. The retreat attendees agreed that the governing board is spending an inordinate amount of resources making few decisions at great expense, in terms of both time and money. The current governance structure is unwieldy and there is redundancy between the governing board and the Management Committee. The election processes leading to membership on the governing board result in members representing factions and being recruited to the board by default rather than intent. Finally, the attend-

ees agreed that resources required to support the current governance structure are not sustainable and are inefficient. The governing board identified five key questions related to AFS governance that need to be answered:

1. Should the governing body maintain the current representation by geography and area of interest or have more of a competency-based membership based on skill and needs and have members serving longer terms?
2. Are the governing board and Management Committee redundant?
3. If we eliminate some governing board members (Coerver and Byers [2011] recommended that governing boards should have no more than five individuals), how do we maintain diversity and leadership development opportunities?
4. How do we change the structure without making subunits (AFS officers, divisions, and sections) feel disenfranchised?
5. Does the board really need to meet face-to-face twice per year, and is it possible to hold meetings via some form of virtual attendance platform?

The retreat attendees decided that a special AFS committee should be formed to begin addressing these questions with the goal of developing alternatives to the status quo that can be reviewed and discussed by the governing board at a future meeting.

In discussing the second radical change, empowering the AFS executive director and staff, the governing board noted that the expertise and capabilities of professional AFS staff should encompass fisheries science and policy, association operations, financial management, membership services, development, publications, technological and database development, and management to meet the needs of the society membership. The retreat attendees offered several solutions to this challenge, including investigating the feasibility of adding a chief operating officer position to AFS staff who reports directly to the executive director, enhancing communications feedback throughout the AFS organization, identifying professionally delivered services that staff can provide directly to AFS units,

Continued on page 521
Overview of Inland Recreational Fisheries in Brazil

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ABSTRACT: This article presents a general overview of recreational fisheries in Brazil, with emphasis on inland fisheries; reports their current needs; and provides directions for future work considering that there is an apparent increase in recreational fishing in emerging economies around the globe. Even though there is no nationwide survey to identify the profile of all Brazilian recreational fishers, some insights can be obtained from competitive fishing events and from the questionnaire printed on the back of fishing licenses. The number of fishing licenses issued in 2010 was approximately 220,000, representing an increase of 220% compared to 2000. Some estimates suggest that the number of recreational fishers in Brazil may be around 10 million. Information on fishing expenses, catch and-release activities, fishing guides, lodging, fishing areas, target species, management control, and fishing clubs and associations is presented. Data for basic estimates such as total number of recreational fishers, total catch and species composition, and total economic value are unavailable, but the results presented here are nevertheless essential for a long-term planning of the development of recreational fishing in Brazil. Other requirements are presented and suggestions are made toward improved management of recreational fisheries in Brazil and other emerging economies.

INTRODUCTION

The diversity of freshwater fishes in Brazil is the greatest in the world, with 3,046 species accounted for at the time of this article (Froese and Pauly 2012). Many of these species are targeted by both Brazilian and foreign anglers. In some regions, such as in the state of Mato Grosso do Sul, catches from recreational fisheries surpass those from commercial fisheries (Catella 2006). In terms of commercial fisheries (fishes and invertebrates), about 30% of Brazilian catch originated from freshwaters in 2009, representing 239,500 tonnes (Ministério da Pesca e Aquicultura [MPA] 2010). Curimatá (Prochilodus spp.), Piramutuba (Brachyplatystoma vaillantii), Jaraqui (Semaprochilodus spp.), Dourada (Brachyplatystoma rousseauxii), and Pescada (Plagioscion spp.) were the most important species and accounted for 38% of total freshwater catch. However, there are no national statistics for total catch or catch composition by recreational fishers.

Competitive fishing is one distinct sector of recreational fishing and is perceived as having both positive and negative effects on the sector as a whole. In Australia, Canada, most European countries, Japan, New Zealand, and the United States, competitive fishing events are very important (Schramm and Harrison 2008). However, for developing and emerging countries (including Brazil), not much is known about the importance of these events and how they affect fish resources and the recreational fishing community. The objective of this article is to provide an overview of recreational fisheries in Brazil, with emphasis on inland fisheries, indicating current needs and giving directions for future work toward their sustainable management. Given that there is an apparent increase in recreational fishing in emerging economies around the globe, it is hoped that the experience in Brazil will be relevant to other countries.
NUMBER OF RECREATIONAL FISHERS

No national survey was conducted in Brazil to estimate the total number of recreational fishers and thus their number is unknown. Since August 2009, all recreational fishers are required to have a license issued, for an annual fee ranging from US$10 to US$30 (see Management Control section), by the MPA to go fishing in either marine or freshwaters. Previously, the license was issued by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA). Recreational fishers younger than 18 years of age are not required to have a license unless taking part in competitive fishing or keeping their catch. Retired recreational fishers and/or those older than 60 years (for women) or 65 years (for men) are also exempted from having to purchase a license, and hence their participation in the sector cannot be properly accounted for either, at least based on licenses.

Data on the number of fishing licenses are available only for the periods 1978–1981 and 1984, when the number of licenses varied between 119,000 and 244,000 (SUDEPE 1978a, 1978b, 1980, 1981, 1984); then, numbers are again available from 1996 onwards, when the National Plan for the Development of Recreational Fisheries (PNDPA) was established. There is no explanation for the decrease in the number of licenses observed from 1996 to 1999 (Figure 1), except for changes in the quality of the database and probably a dissatisfaction of anglers with the management agency (IBAMA by then). During the period 2000–2010, an increase in the number of licenses issued was observed, with an even higher annual increase rate after 2006 of approximately 25,000 licenses. The number issued in 2010 was about 220,000.

In many countries, the number of licenses issued may serve as a proxy to estimate the number of recreational fishers. However, this does not work for Brazil where the overwhelming majority of recreational fishers lack fishing licenses due to poor compliance: 89% in southern Bahia (K. M. F. Freire, unpublished data), 96% in southern São Paulo (Ramires and Barrella 2003), 86% in Espirito Santo (Chiappani 2006), and 75% in northern Santa Catarina (Schork et al. 2010). In addition, regional studies have shown that recreational fishers older than 65 (and thus not required to have fishing licenses) comprised about 15–32% of recreational fishers in some regions, such as São Paulo (Peixer and Petrere 2009).

If we use a mean proportion of license holders in relation to the total number of anglers (13.5%, based on interviews in the states of Bahia, São Paulo, Espírito Santo, and Santa Catarina, as stated above), the total number of recreational fishers in Brazil could be around 1.6 million. That would correspond to approximately 0.9% of the total Brazilian population of about 191 million in 2010 (Instituto Brasileiro de Geografia e Estatística 2010). This participation rate would be smaller than any other presented by Ditton (2008), who reviewed recreational fisheries in nine other countries in the world. On the other hand, IPAAM (2001) estimated the number of recreational fishers in Brazil at 6 million, and da Costa et al. (2006) even suggested a value of 25 million. In view of these various considerations, a figure of 10 million recreational fishers in Brazil would thus appear reasonable.

PROFILE OF RECREATIONAL FISHERS

Although there is no nationwide survey of Brazilian recreational fishers, some insight can be obtained from a questionnaire printed on the back of the fishing license. IBAMA used to issue the license in two ways: (1) via an electronic form available through the Internet and (2) as a printed form. Since 2010, the license has been issued only by the MPA and through the Internet. The information from the printed form was never encoded. Hence, the profile presented in the next section corresponds only to those recreational fishers who obtained a license via the Internet from 2003 to 2009 and is thus biased. The nature of the bias will remain unknown until all of the printed licenses are encoded.

Socioeconomic Profile

Brazilian recreational fishers are mainly males (96%) and middle aged, between 40 and 55 years old (46.5%; mean age = 43 in 2009). Those younger than 18 years or older than 65 years do not have to carry a license, although some did purchase licenses (0.6% and 1.8% of all licenses issued in 2009, respectively). These licenses probably reflect the need to carry a license if planning to take fish home or to enable participation in competitive fishing events, because in both cases a license was required.

A total of 3.3–3.8% of the respondents were not wage earners (which includes students, housewives, and the unemployed). Only 26.6% of these anglers had a monthly wage of more than R$3,000 in 2009 (R$1.00 = US$0.49 for that year). Participation from individuals in this income bracket decreased between 2005 and 2009 and increased for those who earn up to R$1,000. Even though inflation was under control during this period, this change may imply a loss in buying power. For example, a wage of R$3,000 represented 10 times the minimum wage in 2005 but only 6.5 times the minimum wage in 2009.

Fishing Behavior

In 2009, most of the recreational fishers who bought their licenses via the Internet were in category B (70.3%), those who

![Figure 1](image-url)
Table 1: Fishing destination of recreational anglers in 2009 (first row) in relation to the state of residence (first column) (%). The last column presents the number of licenses issued by the state plus the Federal District. Gray cells indicate cases where more than 50% of the respondents go fishing mainly in their state of residence. Squares represent cases where the state of residence is still the most preferred fishing state (but <50%).

| STATE SP | MG | PR | RS | MS | SC | GO | RJ | FD | MT | RO | ES | BA | AM | TO | PE | PA | CE | RN | PB | SE | RR | PI | MA | AC | AL | AP | TOTAL |
|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| São Paulo | 58 | 7 | 2 | 0 | 0 | 0 | 6 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9,526 |
| Minas Gerais | 82 | 0 | 0 | 3 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6,753 |
| Paraná | 62 | 1 | 3 | 5 | 1 | 0 | 1 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4,057 |
| Rio Grande do Sul | 78 | 8 | 2 | 1 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,271 |
| Mato Grosso do Sul | 90 | 0 | 1 | 0 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,001 |
| Santa Catarina | 69 | 1 | 3 | 4 | 9 | 1 | 0 | 1 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,418 |
| Goiás | 68 | 0 | 1 | 14 | 1 | 0 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,363 |
| Rio de Janeiro | 74 | 0 | 4 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,301 |
| Federal District | 62 | 1 | 0 | 1 | 1 | 62 | 1 | 0 | 6 | 1 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,162 |
| Mato Grosso | 82 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,123 |
| Rondônia | 90 | 0 | 2 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 653 |
| Espírito Santo | 57 | 5 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 358 |
| Bahia | 67 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 205 |
| Amazonas | 84 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 191 |
| Tocantins | 84 | 9 | 4 | 3 | 8 | 2 | 3 | 0 | 1 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 653 |
| Pernambuco | 56 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 160 |
| Pará | 56 | 0 | 0 | 0 | 6 | 4 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 155 |
| Ceará | 69 | 0 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 142 |
| Rio Grande do Norte | 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 88 |
| Paraíba | 11 | 1 | 0 | 0 | 10 | 0 | 6 | 4 | 3 | 5 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Sergipe | 9 | 3 | 4 | 7 | 7 | 5 | 7 | 3 | 4 | 1 | 7 | 4 | 9 | 3 | 7 | 7 | 5 | 7 | 1 | 1 | 1 | 1 | 1 | 6 |

**Notes:**
- The Federal District gray cells indicate cases where more than 50% of the respondents go fishing mainly in their state of residence.
- Squares represent cases where the state of residence is still the most preferred fishing state (but <50%).
are permitted to fish from boats. These were followed by category A, those who are not permitted to fish from boats (23.8%), and by category C, spearfishers (5.9%). This does not necessarily reflect the behaviors of all recreational fishers but may be associated with the relationship between access to the Internet and wealthier recreational anglers who are able to afford their own boats.

Most of the licenses were issued in the state of São Paulo (30%), followed by Minas Gerais, Paraná, Rio Grande do Sul, and Mato Grosso do Sul (Table 1). Each of the remaining 21 states accounted for less than 5% of the licenses issued. The preferred destinations followed the same pattern of license sales, with the addition of the states of Mato Grosso and Goiás. The increasing percentage of recreational fishers going fishing in Minas Gerais’ waters was a notable finding: from 6% in 2005 to 20% in 2009, becoming the most important attraction in Brazil (at least as documented for fishers who obtained their licenses from the Internet). The second important pattern was a decrease in São Paulo as an important fishing destination. For 2009, a cross-analysis indicated that most recreational fishers fish in their states of residence (Table 1.)

The majority of recreational fishers licensed through the Internet fish in rivers/lakes and fish-and-pay (about 85% and 31%, respectively, during the period 2006–2009). In the marine realm, sandy beaches/rocky shores were the most cited (17%), followed by offshore areas (10%; Figure 3). A slight increase in the percentage of recreational fishers operating in all freshwater habitats was observed along with a slight decrease in those going offshore.

A total of 62% of recreational fishers stated in 2009 that they fish between 3 and 12 times a year (Figure 4). It is worth noting that the proportion of those avid anglers who go fishing every week to once a month has been increasing. On the other hand, the number of those who rarely go fishing (once a year) has decreased, reaching less than 10% in 2009. The use of natural bait in connection with a rod and reel was the most popular among recreational fishers in 2005–2009 (64–87% and 84–93% of the respondents, respectively). Fly- and spearfishing gear were the least cited during the same period, with less than 4% of the respondents acknowledging their use. During the period from 2005 to 2009, there was a decrease in the percentage of recreational anglers using only rod and line from 14% to 5%, probably due to their awareness that there is no need for a fishing license when using this gear.

Catch-and-release fishing is a concept that has spread among Brazilian recreational fishers since the 1990s (Freire 2005) as a voluntary conservation tool. However, many fishers historically released nontarget species with no consumptive value and specimens that were too small. For the past 5 years, there was no change in the releasing habits: 70% stated that they sometimes release the fish caught, 20% always release, and 10% never release. Considering that minimum size and bag limit are control measurements used in Brazil, recreational fishers are in fact required to release fish in many cases.
tamicus (Capistrano-Santana et al. 2007; data presented only for \( n > 20 \)). In an Amazonian Reserve, preliminary results for *Cichla* spp. indicate a low mean mortality rate of 4.2% after release (Lopes 2011). As previously pointed out by Cooke and Suski (2005), these differences indicate that catch-and-release cannot be seen as a panacea and is not equally applicable for all species and habitats in Brazil.

When analyzing the economic importance of recreational fisheries in Brazil, one should consider the following aspects (for 2009 only):

- Most (75%) recreational fishers do not own boats.
- The percentage of respondents who use fishing guides sometimes, never, and always was 42, 37, and 20%, respectively.
- During their fishing trips, they prefer staying with friends or relatives (44%), in campsites (40%), and fishing hotels or hostels specialized in fishing (38%). They rarely go to standard hotels (5%) or boat hotels (11%).

An analysis of expenses indicated that 50% of the respondents spent up to R$300 per fishing trip in 2005. This percentage increased to 62% in 2009. In general, the other categories (R$301–1,000; R$1,001–2,000; > R$2,000) represented less than 30% of the respondents, and a decreasing trend through time was observed. We should point out that these expenses pertain to residents and exclude expenses by foreign recreational anglers, who increasingly see Brazil as a desirable fishing destination. However, there is no national estimate indicating the importance of these data. Preliminary results indicated that 299 licenses were issued to non-Brazilians in 2011, when 7,230 tourists were expected to go fishing in Amazonian waters, most of them from the state of São Paulo and from the United States (Anonymous 2011). In the state of Amazonas, tourists usually spend R$3,500–4,000 for a 3- to 7-day trip (US$1.00 = R$2.04).

**FISHING CLUBS OR ASSOCIATIONS**

Fishing clubs or associations (hereafter only referred to as fishing clubs) were split into two broad categories: official and unofficial. The former are recognized by the Brazilian Confederation of Sport Fishing and Underwater Sports (CBPDS), which gives support to so-called official competitive fishing events. Currently, there are 49 official fishing clubs in Brazil but many more unofficial fishing clubs; the total number of fishing clubs is unknown. For the northeastern region, Freire (2010) found a total of 31 fishing clubs in 2009, even though only 9 clubs are currently affiliated with the CBPDS.

Fishing activities are also promoted by clubs created for other recreational purposes. Some of these were established as early as 1930, but most were created since 1985. Not all fishing clubs promote competitive events, and their members fish in events promoted by other clubs. Some fishers are affiliated with more than one fishing club.
Brazil was divided by the Brazilian Water Agency into 12 basins that reflect different species/group of species (Figure 5). Theoretically, these basins work as management units for recreational fishing. Some of the control measures (minimum size and bag limits) are basin specific, but in general the control level is poor.

**TARGET SPECIES AND TOTAL CATCH**

The total number of species targeted by recreational fishers in Brazil is unknown. The PNDPA used to publish an annual guide of fishing records for Brazil, based on the International Game and Fish Association (IGFA) records (PNDPA 2009; IGFA 2011). These records provide an idea of some species caught by recreational fishers in Brazilian inland waters (75 native and 2 introduced; Table 2, Figure 6), though many Brazilian records are not listed by the IGFA because they do not meet the IGFA’s strict requirements. Most of the species recorded were not assessed for their conservation status (74% according to the International Union for Conservation of Nature 2010), but some are listed as threatened (IBAMA 2004). Introduced species include the largemouth bass *Micropterus salmoides* and the rainbow trout *Oncorhynchus mykiss*.

The total catch of each species is known for only some regions. In southern Pantanal, the mean catch for 1994–1997 was about 1,086 tons∙year⁻¹, with a yield per recreational fisher∙day of 3.6–6.2 kg (Catella and Albuquerque 2000). From 2001 to 2003, the mean catch rate was 329 tons∙year⁻¹ with a yield of 2.1–3.8 kg/fisher∙day (Albuquerque et al. 2003; Catella and Albuquerque 2007). It is thought that this decrease in bag limits is one of the factors leading to decreasing numbers of recreational fishers visiting the southern Pantanal region (from 60,000 in 1997 to fewer than 20,000 in 2003). Much higher values were obtained in other regions, some of them surpassing bag limits (see Management Control Section): 21.2 kg/fisher∙day for Marmelos River (Crepaldi et al. 2010), 36.2 kg/fisher∙day for Jauaperi River in the states of Amazonas and Roraima (Crepaldi and Machado 2010), and 39.4 kg/fisher∙day for Anauá River in the state of Roraima (Machado and Crepaldi 2009).

**FISHING AREAS**

Brazil was divided by the Brazilian Water Agency into 12 basins that reflect different species/group of species (Figure 5). Theoretically, these basins work as management units for recreational fishing. Some of the control measures (minimum size and bag limits) are basin specific, but in general the control level is poor.

**TABLE 2. Some of the main native species caught by anglers in Brazilian inland waters (based on PNDPA [2009] and most cited in two magazines specialized in recreational fishing in 2010–2012), their common names in Portuguese (italic) and English (presented within parentheses; from FishBase), maximum size (total length or otherwise stated), maturity length (total length; female values used when informed), occurrence by basin, and minimum catch size per basin, if defined. Gray boxes represent basins where species are caught by recreational fishers.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Common names</th>
<th>Mat. size (cm)</th>
<th>Basins</th>
<th>Portugese (English) name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachyplatystoma filamentosum</td>
<td>Filhote, Piraíba (Kumakuma)</td>
<td>NA e</td>
<td>Am</td>
<td>Filhote, Piraíba (Kumakuma)</td>
</tr>
<tr>
<td>Cichla piquiti</td>
<td>Tucunare-azul (NA e)</td>
<td>43.0 SL</td>
<td>TX</td>
<td>Tucunare-azul (NA e)</td>
</tr>
<tr>
<td>Cichla temensis</td>
<td>Tucunare-açu, tucunare-paca</td>
<td>99.0</td>
<td>TX</td>
<td>Tucunare-açu, tucunare-paca</td>
</tr>
<tr>
<td>Colossoma macroporum</td>
<td>Tambaqui (Cachama)</td>
<td>108.0</td>
<td>TX</td>
<td>Tambaqui (Cachama)</td>
</tr>
<tr>
<td>Hoplias malabaricus</td>
<td>Traira (Trahira)</td>
<td>55.2</td>
<td>TX</td>
<td>Traira (Trahira)</td>
</tr>
<tr>
<td>Leporinus obtusidens</td>
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<td>49.3</td>
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<tr>
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<tr>
<td>Pseudoplatystoma fasciatum</td>
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<td>104.0</td>
<td>TX</td>
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<tr>
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<td>Dourado (Dorado)</td>
<td>111.3</td>
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</tr>
</tbody>
</table>

- aAccording to FishBase.
- bTotal length from FishBase. SL = standard length. Converted to total length when length–length relationship available in FishBase.
- cFrom PNDPA (2009) or FishBase. Values presented for females.
- dAm = Amazonia; TA = Tocantins–Araguaia; Prn = Parnaíba; Sfr = São Francisco; Wna = western northeast Atlantic; Ena = eastern northeast Atlantic; Ea = eastern Atlantic; Sea = southeast Atlantic; Sa = South Atlantic; Par = Paraná; Prg = Paraguay; Urg = Uruguay (based on PNDPA 2009).
fishing from boats and C for spearfishers). These values have not changed since 1998. All recreational fishers caught without a license are required to pay fines ranging from US$147 to US$4,900 plus US$9.8 per kilogram of fish they hold (R$300 to R$10,000 plus R$20 per kilogram), and their fishing gear is confiscated. However, enforcement is poor. Control is more effective in official competitive events where fishing licenses are required. The fishing license, as required by federal regulation, is valid nationwide; however, some states, such as Amazonas, Mato Grosso do Sul, Pará, and Tocantins, require an additional license according to state regulations, which can vary from about US$8 to US$78 per year.

Catch control was introduced in 1967, with a bag limit of 50 kg plus one fish for both marine and inland waters. In 1989, it was reduced to 30 kg plus one fish. In 2003, this limit was decreased to 10 kg plus one fish (any species) when fishing in inland waters (5 kg less than in marine waters), and it is the catch control currently adopted. In some cases, according to specific state regulations, these limits may be more restrictive (the strictest is 5 kg or one fish in the state of Tocantins). The scientific basis for such differences is unknown.

In addition to the fishing license and bag limit, another common management control is the use of minimum size (length) limits. Most of the target freshwater species are managed under this regime, with minimum size differing among basins (Table 2). However, for many species, the size at first maturity is not known, which raises doubt about the scientific basis of the different minimum sizes established for different basins.

A research project was established by the PNDPA in the state of Goiás, together with local hotels and fishing companies, in order to try to establish the maximum size of tucunare azul (Cichla piquiti), which represents about 95% of total catch in that region. The purpose of this project was to obtain information that will help protect genetic diversity, allowing larger fishes to continue populating the area. The first phase of the project was concluded, and a maximum catch size of 50 cm was recommended. This control measure adds to the already existing minimum size limit (35 cm) for a species that can reach a maximum size of 73 cm, thus creating a size window (i.e., allowable slot limit) for fishing. The catch per unit effort (CPUE) for this window was approximately 5.2 kg/fisher-day, which is larger than the daily quota allowed for that state. Further, only 6% of the catch of C. piquiti includes species larger than 50 cm. However, the recommendation of a size window for C. piquiti in Goiás was rejected without explanation by the Ministry of Fisheries and Aquaculture.

Brazil also closes seasons as an additional measure of control. Closed seasons are established according to the spawning period of Brazilian freshwater species targeted by recreational and commercial fishers. In general, the closed season begins in November and runs until February in most of the Brazilian river basins.

### COMPETITIVE FISHING

According to the Brazilian legislation, the promoters of competitive fishing events are required to obtain an authorization from the government for each event held. Until 2009, IBAMA—later replaced by the Ministry of Fisheries and Aquaculture—was in charge of issuing this authorization. However, little information is available on these events and their outcomes (total catch, number of species caught, and number of anglers). Only recently have these data been compiled in a database indicating that 269 competitive fishing events (90 per year) were authorized from 2009 to 2011 (incomplete), most of them in marine waters (60%; Table 3). This number is an underestimate of the number of fishing events promoted in Brazil; Freire (2010) estimated a total of 100 events for the northeastern region alone. In marine waters, most of the authorizations were for events that took place on sandy/rocky beaches. In inland waters, most of them were for reservoirs in 2010 and for rivers in 2011.

In 2009–2011, only 40% of the authorized events were based exclusively on catch-and-release. In fresh waters, a total of 76% of the events were catch-and-release oriented. For marine waters, the opposite was observed, with 14% of the events featuring catch-and-release only. The distribution of fishing events throughout the year from 2009 to 2011 was bimodal, with a peak in March and another large peak in October. In freshwater fishing events authorized by the Ministry of Fisheries and Aquaculture, 16 to 800 competitors were involved (average = 141 per event) in fishing competitions that took place on boats. For those fishing events based onshore (no boats involved), 14 to 4,000 recreational anglers were reported (average = 483). Some of them involved teams (2–3 recreational fishers), and others were individual. Some events had a single target species (e.g., blackbass, Micropterus salmoides; peacock bass, Cichla spp.; snook, Centropomus spp.) but in others all species were valid. Total catch from these events ranged from 1 to 1,050 specimens (average = 218) and from 16 g to 250 kg (average = 58 kg).

### FUTURE DIRECTIONS

As previously shown, the number of licenses sold in Brazil represents less than 15% of our minimum estimate of the number of recreational fishers (1.6 million). Even though the license fee has not increased since 1998, if all of these potential fishers would pay individual licenses, it would generate revenues six times higher (i.e., at least US$50 million).
fund research leading to a better estimate of the number of recreational fishers in the country and also provide funds for better management of the fisheries. Thus, promoting the license system would seem to be important, because there is no widespread awareness of the need of licenses for recreational fishers. Additionally, all organizers of fishing competitions (official and nonofficial) must require licenses from their participants. The media specializing in recreational fishing and tourism operators could be involved in this task. A special form of registration for children and retired/elders is also needed, free of charge, which would allow for their activities to be monitored as well. Due to the poor current enforcement power of the governmental agencies in many developing countries and economies in transition, it is important to have other mechanisms to monitor the activity. Relying on the cooperation among recreational fishers, fishing clubs and associations, and tourism agencies may be one option.

The requirement of a fishing license is based on the “user pays–user benefits” principle. In recent years, Brazilian law has allowed the revenue from fishing licenses to be used for enforcement. However, the lack of implementation leads to dissatisfaction among license holders. Reversing this trend is essential to increase the number of licensed recreational fishers. Communicating the results from the questionnaires here may be one step toward this aim. Thus, once fishing licenses are widespread, they can become a fundamental tool for qualitative and quantitative studies of recreational fisheries.

Brazil has not been able to put in place a reliable collection system of catch statistics for commercial fisheries (Freire and Oliveira 2007). As stated above, there is no such a system for recreational fisheries either. Thus, currently, we are not able to quantify total extraction by recreational fishers or characterize the composition of their catch. The Expert Consultation to Develop the Food and Agriculture Organization (FAO) Technical Guidelines for Responsible Recreational Fisheries, which convened in 2011, recommended that FAO should request members to collect and submit disaggregated data and information on recreational fisheries catches and participation (FAO 2011). Brazil and other developing countries/economies in transition have to start moving in that direction to be able to fulfill this agenda if this recommendation is accepted. We could use the experience of a well-established program for the collection of catch statistics from recreational fisheries in the state of Mato Grosso do Sul (15 years) and adapt to other states and habitats (there is no similar initiative for marine waters). As a starting point, one could think of a voluntary Internet-based system for catch reporting. The results obtained must then be used to plan a well-structured sampling design; and strategies implemented by the National Oceanic and Atmospheric Administration (van Voorhees et al. 2011) and by the Northern Research Institute in Norway (Volstad et al. 2011) could then be revised for guidance. Some of these sampling programs are very expensive and budget constraints will have to be considered. Here again we stress the importance of fishing license revenues to cover part of the sampling costs. Another important source of information on catches comes from competitive events. The Ministry of Fisheries and Aquaculture is expected to demand that reports from these events be delivered with all required details; otherwise, permission for further competitions would not be provided. Thus, it should be possible to obtain an initial estimate of catch composition, at least from competitive fishing events.

Catch-and-release has been widely promoted and adopted in Brazil. In 2009, 90% of the licensed recreational fishers stated that they release fish either sometimes or always. The rationale that “a fish released is a fish alive” has led to the proposal of closure of some areas for commercial fishing, with exclusive access for recreational fishers, which has generated serious conflicts. The use of fish resources needs to be embedded in integrated management plans, in order to consider other players besides those associated with tourism and sports. Recreational fishing is not an impact-free activity, and its real impact on the resources provided should be properly assessed. Total catches, including released fishes, must be reported to keep track of the real impact of this activity. The promotion of catch-and-release has to be linked with well-conceived studies of postrelease mortality. These studies are very scarce in Brazilian freshwaters and probably in other emerging countries. International partnership could be established to develop standardized protocols for these studies to allow for comparison among regions. Such partnership for marine waters will be more challenging, because studies are currently more concentrated in freshwaters worldwide (Cooke and Suski 2005).

Another impact of this activity is the introduction of target species in other water bodies (a problem already common in Brazil; see, e.g., Luiz et al. 2011). In addition, the impact of the introduction of live bait cannot be ignored, especially considering that most anglers in Brazil prefer natural bait (87% in 2009), especially in marine waters, and that higher postrelease mortality rates have been associated with live baits (Cooke and Suski 2005).

The quota system currently used in Brazil is basin based and multispecific but does not take into consideration the status of the stocks and the effort that is more concentrated on species with the highest recreational value. New information should allow for moving toward a species/stock-specific quota system, but information on sizes at first maturity is missing for many species targeted by recreational fishers (Table 2). Thus, the promotion and development of recreational fisheries in Brazil—and, by extension, in other economies in transition or developing countries—require research programs that are able to generate and provide basic information. Such research programs could use part of the revenue generated by fishing licenses but also receive grants from other agencies. Here, management agencies would request and/or fund research institutions to carry out studies on population dynamics (size at first maturity, reproduction season, and growth) for the main target species. However, due to the richness of species targeted in Brazilian waters, agencies may consider the use of proxies to estimate important parameters, such as size at first maturity based on the asymptotic or maximum length, as proposed by Froese and Binohlan (2000). Such data would also allow the
Construction of models capable of predicting the likely impacts of long-term fishing activities (both commercial and recreational), such as Ecopath with Ecosim (EwE), one of the most widely used and best tested platforms for the examination of indirect effects of fishing (Christensen and Walters 2004). However, to date, though many EwE models have been built in Brazil (e.g., Angelini and Gomes 2008; Freire et al. 2008), none of them includes the effect of recreational fisheries, mainly due to lack of basic catch data.

Management objectives for recreational fisheries are different from those traditionally defined for commercial fisheries, which must be reflected in any management plan for fisheries. The three indicators to deal with overexploitation proposed by Froese (2004) could be a good option due to the expected ecological benefits: (1) percentage of mature fish in catch, with 100% as target; (2) percentage of specimens with optimum length in catch, with 100% as target; and (3) percentage of mega-spawners in catch, with 0% as target. Thus, the idea of having large specimens available to be caught (and released) is very attractive for recreational fishers. This would lead to regulations that add a maximum allowable size to the already well-established minimum allowable size for many species. However, this so-called size window may not be suitable for all local species—hence the interest in estimating fishing and natural mortality rates, as well as recruitment and growth rates. Knowledge of these rates would allow for the assessment of the best suitable regulation among the five most common size-based regulations applied in recreational fisheries (FAO 2011).

Economic analyses of recreational fisheries also need to be carried out, notably to allow for comparison with benefits accrued from commercial fisheries. Venturieri (2000) estimated that revenues of more than US$300 million are generated by fish-and-pay enterprises in Brazil. Shrestha et al. (2002) calculated a recreational fishing value of US$35–56 million for the Brazilian Pantanal. However, there has been no attempt to date to quantify the total economic value of recreational fisheries at the national level. Fishing tourism is perceived as one important benefit of recreational fishing. Nevertheless, there is a usual complaint that many tourists visit remote areas with minimum contribution to local communities, as suggested by our findings that most recreational fishers stay with friends or relatives (44%) or in campsites (40%) during their fishing trips. Studies quantifying this contribution for major destinations, including those visited by international fishers, are essential if this activity is to be further promoted.

Information gathered about recreational fishing would be most useful if made widely available through the Internet so recreational fishers would see why it is necessary to pay for fishing licenses. Transparency could be the key to securing the collaboration of recreational fishers and tourism operators. Information could be provided in the form of an easy-to-query database, instead of long reports (a task not yet fulfilled even by the commercial sector in Brazil).

A fragile institutional framework could be a limitation for any program that considers all of these points. Freire (2005) listed the institutions responsible for managing recreational fisheries since the 1930s. Since 2009, the Ministry of Fisheries and Aquaculture has been in charge of this activity. During this period some conflicts with the previous managing agency, IBAMA, were observed. Moreover, a succession of three ministers of the Ministry of Fisheries and Aquaculture in 2011 precluded any initiative to organize and develop this sector. The establishment of a collection system of catch statistics would have to take this into account—for example, by relying on very well-established fishing clubs, associations, or federations—thus allowing for continuity even during government transition periods. However, even these institutions have suffered from conflicts of interest (e.g., between official and nonofficial fishing clubs or between catch-and-release and catch-and-kill-oriented recreational fishers), which have to be overcome to benefit the activity as a whole.

CONCLUSION

As evident from the above profile, recreational fisheries in Brazil represent a growing fishing sector. However, the profile is incomplete, particularly with respect to information on overall effort, catch, and harvest. Moreover, little is known about the population biology of many of the species that are targeted, and even less is known about how different species respond to recreational fishing pressure (e.g., catch-and-release mortality). Unfortunately, this is a reality for other developing countries and economies in transition and must be addressed in order to inform the development of rational and effective fisheries management plans. Many of these countries have also become an alternative destination for recreational fishers from other countries, who are trying to escape from overcrowded fishing grounds and depleted resources. Hence, there is some urgency to ensuring that management actions will promote sustainable fisheries.

We hope that this overview sheds some light on recreational fisheries in Brazil and may lead to increased sharing of knowledge, including partnerships with international organizations. We expect, finally, that some of the information provided here may be used by other developing countries or economies in transition whose recreational fisheries are facing problems similar to Brazil’s.

ACKNOWLEDGMENTS

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From the Archives

The question of the digestibility of foods is very complex, and it is noticeable that the men who know most about the subject are generally the least ready to make definite and sweeping statements concerning it. One of the most celebrated physiologists of the time, an investigator who has, I suppose, devoted as much experimental study to this particular subject as any man now living, declares that aside from the chemistry of the process and the quantities of nutrients that may be digested from different foods, he is unable to affirm much of anything about it. The contrast between this and the positiveness with which many people discourse about the digestibility of this or that kind of food, is very marked and has its moral.


From all over the land there is a murmur of complaint about the pollution of our creeks and rivers by manufacturing companies, dyeing establishments, saw mills, and the like; and while the general Government, States and individuals are working to re-stock our nearly exhausted rivers, lakes and streams, this pollution is allowed to go on unheeded and unchecked.

Fred Mather (1875): Poisoning and Obstructing the Waters, Transactions of the American Fisheries Society, 4:1, 14–19.
Management of Alewife Using Pacific Salmon in the Great Lakes: Whether to Manage for Economics or the Ecosystem?

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ABSTRACT: The combined destructive effects of overfishing, habitat destruction, and invasive species, especially alewife (Alosa pseudoharengus) and sea lamprey (Petromyzon marinus) led to the loss of the native top predator lake trout (Salvelinus namaycush) from most of the Great Lakes by 1960. Alewife populations then exploded, creating nuisance die-offs. Public demands for action, coupled with control of sea lamprey, allowed fishery managers to consider stocking Pacific salmon to control alewife and establish a recreational fishery. This effort was successful, reducing alewife numbers and creating a recreational fishery that is estimated at $7 billion annually. This fishery management regime may no longer be viable as new invasive species continue to alter the ecosystem. Fishery managers face an interesting dilemma: whether to manage in the short term for a popular and economically important sport fishery or to embrace ecosystem change and manage primarily for native fish species that appear to be better suited to ongoing ecosystem changes. Such dilemmas occur in great lakes around the world as fishery managers seek to balance economic pressure with changes in their respective ecosystems, often brought about by invasive species.

INTRODUCTION

Historically, fish communities of the Laurentian Great Lakes were dominated by the top predator lake trout (Salvelinus namaycush) and a diverse assemblage of uniquely adapted coregonine fishes. These communities were relatively intact until the early 1900s, by which time overfishing and invasive species began to impact the native fish community (Stein and Goddard 2006). The alewife (Alosa pseudoharengus), a pelagic planktivore native to the Atlantic Ocean, was first seen in Lake Ontario in 1873 (Smith 1970), entering via the Hudson–Mohawk River drainage, the New York Finger Lakes, and the Erie canal (Ihssen et al. 1992). Similarly, the parasitic sea lamprey (Petromyzon marinus) was first observed in Lake Ontario in 1835 (Lark 1973), most likely entering the lake via the same route (Smith 1995). There is some recent speculation, however, that sea lamprey are native to Lake Ontario and Lake Champlain, migrating from the Atlantic Ocean via the St. Lawrence River postglaciation (Daniels 2001; Bryan et al. 2005), but see Eshenroder (2009) for another perspective.

Overfishing became a fishery management issue during the late 1800s, as stocks of lake trout, Atlantic salmon (Salmo salar), lake sturgeon (Acipenser fulvescens), and some coregonines were overharvested (R. W. Brown et al. 1999). By the early 1900s, the complex of coregonine fishes was showing signs of overfishing, with several endemic species of this flock driven extinct by the middle of the 20th century (Eshenroder
and Burnham-Curtis 1999). Meanwhile, sea lamprey and alewife invaded the upper four Great Lakes after enlargement of the Welland Canal (Christie and Goddard 2002). Sea lampreys were first recorded in Lake Erie in 1921 (Sullivan et al. 2003) and in the rest of the Great Lakes by 1938. Alewives were widespread, except in Lake Superior, by 1960 (O’Gorman and Stewart 1999). In addition, by 1960, the combination of overfishing and predation by sea lamprey resulted in the extirpation of lake trout in all of the Great Lakes except Lake Superior. Without the native top predator in these systems, alewives became the dominant portion of fish biomass in three of the four deep lakes (Michigan, Huron, and Ontario) by 1965, where they exerted strong negative impacts on many native fishes (Madenjian et al. 2008).

Alewives consume pelagic early life stages of several native fishes, including yellow perch (Perca flavescens; Brandt et al. 1987) and lake trout (Krueger et al. 1995; Madenjian et al. 2008). Alewives also compete directly with coregonines, given their ability to consume large quantities of zooplankton (Smith 1970; Crowder 1980). In fact, the width between gill rakers of bloater (Coregonus hoyi) increased to allow bloater to feed more effectively on larger bodied prey than zooplankton, after alewife dominated the fish biomass (Crowder 1986). Moreover, alewives appear to exert their own negative reproductive influence on salmonines through indirect means. Alewives carry high body burdens of thiaminase (Tillitt et al. 2005), an enzyme that denatures thiamine. Thiamine is an essential compound in the early development of salmonines, and too little thiamine will cause death or impair the function of early life stages (S. B. Brown et al. 1998), a condition termed “thiamine deficiency complex.”

Control of Sea Lamprey and Alewives

Recognizing the damage inflicted by sea lamprey, the United States and Canada established the Great Lakes Fishery Commission in 1955 for the purpose of controlling sea lamprey. By 1960, treatments for sea lamprey were undertaken and sea lamprey numbers have been reduced to about 10% of previous highs in most lakes, allowing standard fisheries management activities to be successful, including rehabilitation of lake trout in Lake Superior (Hansen et al. 1995). Sea lamprey control efforts, along with release from alewife predation since 2003, have permitted increasing levels of natural lake trout reproduction in Lake Huron (Riley et al. 2007). Successful treatments for sea lamprey also set the stage for reintroduction of the native top predator lake trout throughout the rest of the Great Lakes basin.

Alewife dominated the fish communities of Lakes Michigan, Huron, and Ontario during the 1960s (O’Gorman and Stewart 1999). In Lake Michigan, alewife exceeded the lake’s carrying capacity (E. H. Brown 1972), resulting in massive die-offs that littered shorelines and fouled beaches (E. H. Brown 1972; O’Gorman and Stewart 1999). These die-offs resulted in intense political pressure to develop an effective method to control alewives. With effective sea lamprey control, along with renewed efforts to reintroduce lake trout—the native top predator—fishery managers supported the development of commercial trawl fisheries to reduce alewife populations. Managers also sought to stock pelagic piscivores to further reduce the abundance of alewives.

Establishment of Thriving Sport Fisheries for Pacific Salmon

To this end, managers stocked Pacific salmon as predators to control alewife, while also seeking to establish a viable recreational fishery for salmon (Tanner and Tody 2002). The state of Michigan first began this practice in earnest by stocking coho salmon (Oncorhynchus kisutch) into Lake Michigan in 1966 and subsequently Chinook salmon (O. tshawytscha) in 1967 (Tanner and Tody 2002). This strategy worked well in Lakes Huron, Michigan, and Ontario, because the Pacific salmon, especially Chinook salmon, consumed large quantities of alewives, thus reducing alewife populations (Madenjian et al. 2002). By 1984, the biomass of alewives in Lake Michigan was less than 20% of what it had been in 1967 (O’Gorman and Stewart 1999). This shift away from a community dominated by alewife resulted in a more diverse fish community well represented by native fishes during the 1980s and 1990s (Bunnell et al. 2006).

As envisioned by the state of Michigan, an extensive and popular recreational fishery for Pacific salmon developed throughout the Great Lakes. By the late 1970s, catch rates of Pacific salmon were high, and large Chinook salmon (up to 15–20 kg) were harvested by recreational anglers. The phenomenally popular recreational fishery also led to widespread establishment of a successful charter boat industry for stocked Pacific salmonids. This recreational fishery provided significant economic return to the Great Lakes states and the Province of Ontario. To protect the recreational fishery, the state of Michigan banned commercial harvest and sale of lake trout and Pacific salmon and use of large mesh gill nets—forcing commercial fishers to shift to impoundment gear, for which they were compensated by the state (Talhelm 1978; Lupi and Jester 2002).

Based on this success, management agencies also stocked steelhead (O. mykiss) and brown trout (Salmo trutta) to increase the diversity of fishing opportunities in the Great Lakes (Bence and Smith 1999). Steelhead and brown trout have become naturalized in some locations of the Great Lakes (Tanner and Tody 2002; Johnson et al. 2010), allowing for excellent angling opportunities in both open-lake and tributary environments for these fish, as well as for coho and Chinook salmon (Bence and Smith 1999).

Management agencies stocked Pacific salmon in increasing numbers, with more than 25 million being stocked into the Great Lakes basin during the early 1980s (Kocik and Jones 1999). Initially, managers were quite pleased with stocking results, because harvest increased linearly with stocking. As populations of alewife declined during the 1980s, the size of
salmon also declined (Hansen and Holey 2002), setting the stage for a large die-off of Chinook salmon in Lake Michigan during the late 1980s due to bacterial kidney disease (Holey et al. 1998). This die-off occurred, in part, because fewer alewifes were available for consumption by Chinook salmon, which reduced their overall condition and, thereby, allowed bacterial kidney disease to be expressed. The resulting low abundance of Chinook salmon led to extremely low catch rates of salmon for several years after the die-off (Holey et al. 1998).

Low catch rates of Chinook salmon created a significant and controversial management issue, with a reevaluation of Chinook salmon as the primary predator suggested by Holey et al. (1998). The popularity and resultant economic benefit of the Pacific salmon fishery fostered significant political influence by recreational fishers, who demanded that alewife populations be maintained at levels sufficient to sustain the Pacific salmon fishery. As a result, management agencies eliminated commercial fisheries for alewife by 1991 because the commercial fisheries competed with salmon for alewife (O’Gorman and Stewart 1999). Similarly, a court settlement ordered the owners of a pumped-storage, power generating facility to pay restitution, because operation of the facility on Lake Michigan impinged and killed large numbers of several species of fish, particularly alewife.

Recreational fisheries in the Great Lakes are estimated to be valued at more than $7 billion annually (American Sportfishing Association 2008), compared to commercial fisheries valued at more than $200 million (R. W. Brown et al. 1999). Because of the popularity and large economic impact of salmon fishing, fishery management agencies increasingly sought to manage Lakes Michigan, Huron, and Ontario to maintain alewife populations, albeit at levels well below those observed in the 1960s and 1970s, to provide the requisite forage base for smaller, but healthier, populations of Pacific salmon. To this end, several fishery management agencies have collaboratively developed an indicator-based decision model derived from a variety of biological observations to aid in annually determining the number of Chinook salmon to be stocked (Table 1). This decision model was used to support a reduction in stocking of Pacific salmon by the Lake Michigan management agencies for the first time in 1998 (Kocik and Jones 1999), in 2006, and again in 2012.

Cooperative fishery management in the Great Lakes occurs in a nonbinding, consensus-based approach as outlined in A Joint Strategic Plan for Management of Great Lakes Fisheries (Gaden et al. 2009). As such, all of the jurisdictions with fishery management authority in each Great Lake (lake committees) meet at least annually in a public forum to decide on management goals, objectives, and actions, including the long-term objectives for the desired fish community. Each lake committee has developed fish community objectives to guide management in its particular lake. Generally, the fish community objectives adopted by fishery managers recognize the importance of increasing the proportion of naturally produced fish and of restoring native fishes decimated by sea lamprey predation, overfishing, and impacts of alewife, while maintaining popular fisheries for Pacific salmon.

The collaborative and consensus-based decision by the fishery management agencies to reduce stocking of Chinook salmon—while also not increasing stocking of lake trout to recommended levels—to maintain alewife populations in Lakes Michigan and Huron reflected—as did stocking reductions of Chinook salmon in Lake Ontario—the difficulty facing managers seeking to maintain popular and economically important sport fisheries while also seeking to restore native fishes. The dominant management philosophy had evolved to establish a balance between Pacific salmon and their alewife prey as the primary goal. To accomplish this, the agencies reduced stocking of Pacific salmon in an attempt to balance predator abundance with lower levels of alewifes to maintain a highly valuable, but smaller, recreational fishery for Pacific salmon. At the same time, decisions about how to proceed with lake trout rehabilitation languished in Lake Michigan for over a decade. Calls for a revision to Lake Michigan’s lake trout rehabilitation plan began by 2000 (Holey and Trudeau 2005). A guide for rehabilitation of lake trout in Lake Michigan was published in 2008 (Bronte et al. 2008), but the Lake Michigan Committee did not adopt a strategy for lake trout rehabilitation until 2011 (Dexter et al. 2011), when it chose to stock fewer lake trout than recommended by Bronte et al. (2008).

### Impacts of Additional Invasive Species

Further confounding management, another wave of invasive species has entered the Great Lakes, creating food web changes that are ongoing and not yet well understood (Pangle et al. 2011), when it chose to stock fewer lake trout than recommended by Bronte et al. (2008).

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**Table 1. Indicators used by fishery management agencies on Lake Michigan in 2009 to determine whether changes in the number of Chinook salmon stocked was warranted to manage alewife populations for good growth of salmonines.**

<table>
<thead>
<tr>
<th>Indicator Type</th>
<th>Indicator</th>
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<tr>
<td>Chinook salmon abundance</td>
<td>Estimated lakewide harvest</td>
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<tr>
<td></td>
<td>Catch rate from charter boats</td>
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<td></td>
<td>Illinois harbor survey CPE and</td>
</tr>
<tr>
<td></td>
<td>Michigan weir returns</td>
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<tr>
<td>Measure of natural reproduction</td>
<td>Proportion of naturally produced Chinook salmon</td>
</tr>
<tr>
<td>Chinook salmon growth</td>
<td>Weight of Chinook salmon at age 2 (creel data)</td>
</tr>
<tr>
<td></td>
<td>Weight of Chinook salmon at age 3 (creel data)</td>
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These new invasive species are exerting far-reaching impacts on energy flow throughout the system. Dreissenid mussels filter a substantial amount of annual primary production (Madenjian 1995). Because this tremendous filtering capacity may redirect primary production from offshore pelagic areas to nearshore benthic areas (Hecky et al. 2004), another fundamental shift in community structure is now occurring in the Great Lakes. In particular, the relative amount of energy available to the pelagic portion of the food web has declined compared to the amount of energy entering the benthic portion of the food web.

Across Lakes Michigan, Huron, and Ontario, remarkably similar ecological changes are occurring. Phytoplankton abundance and composition has changed, reflecting gradual, long-term oligotrophication since the Great Lakes Water Quality Agreement of 1972 and recent effects of dreissenid mussels (Evans et al. 2011). Of particular concern to fishery managers is the increased concentration of water column silica (Evans et al. 2011), which fuels the spring bloom of diatoms. The increased concentration of silica in the water column during spring, when it should be incorporated into diatoms, means that diatom production has declined (Evans et al. 2011), leaving less desirable phytoplankton available for zooplankton grazing. In turn, diatoms are a favored food of cladoceran zooplankton, which are consumed by prey fish, including alewife and rainbow smelt Osmerus mordax. Zooplankton composition has shifted away from dominance by cladocerans during summer months to dominance by large calanoid copepods (Barbiero et al. 2009). This shift is likely related to reduced nutrient availability and to the combined direct and indirect effects of the invasive invertebrate predator Bythotrephes longiramus (Pangle et al. 2007; Barbiero et al. 2009; Bunnell et al. 2011). Cladoceran zooplankton move deeper in the water column below the thermocline to avoid predation by Bythotrephes but suffer from dramatically reduced reproductive potential in the much colder epilimnetic waters. The combined effect of these food web changes may mean much reduced availability of prey for alewife and Chinook salmon.

Since the mid-1990s, dreissenid mussel populations have exploded in Lakes Michigan, Huron, and Ontario (Watkins et al. 2007; Nalepa et al. 2010) at the expense of the native deepwater amphipod Diporeia in all three lakes (Watkins et al. 2007; Nalepa et al. 2009; Barbiero et al. 2011). In Lake Michigan, Diporeia densities averaged 5,365/m² in 1995 but were just 329/m² in 2005 (Nalepa et al. 2009).

Further, the energy density of adult alewife in Lake Michigan has declined by 23% since dreissenid mussels invaded the lake (Madenjian et al. 2006), as the importance of Diporeia in their diets declined. Functionally, this means that the current capacity of lower trophic levels to support alewife, and hence Chinook salmon, has been reduced since 1990. Alewives collapsed during 2003 in Lake Huron as a result of a combination of increased predation by Chinook salmon and double-crested cormorants (Phalacrocorax auritus) and successive years of poor recruitment (Bence et al. 2008); alewife remain nearly absent from this ecosystem since their collapse. Overall, the prey fish biomass in Lake Huron has declined by 87% since 1984 (Roseman and Riley 2009).

The resources that are available, however, support benthic-oriented native fishes such as coregonids and lake trout. This trend toward a benthic-dominated food web may become even more pronounced if the invasive bighead carp (Hypophthalmichthys nobilis) and silver carp (H. molitrix) become established in the Great Lakes and further decrease the availability of pelagic plankton. Interestingly, such changes likely will benefit coregonids and lake trout—native fishes that are adapted to the deep, less productive state that many Great Lakes are moving toward and that may be a more sustainable community in the long run (Eshenroder and Burnham-Curtis 1999).

Other important changes in the ecosystem occurred as Pacific salmon and other introduced salmonids became naturalized. Substantial natural reproduction of Chinook and coho salmon has been documented in Lakes Michigan and Huron (Carl 1983, 1984; Bence et al. 2008; Jonas et al. 2008) and also occurs in Lake Ontario (Ribey and Chapleau 1996; Conerton et al. 2009). A marking study documented that 80% of Chinook salmon in Lake Huron were naturally produced during 2000–2003 (Johnson et al. 2010). Johnson et al. (2010) further estimated that wild production during this period could have been as high as 18 million Chinook salmon annually, compared with the 3.5 million fish stocked annually by management agencies. Given the extensive natural reproduction of Chinook salmon occurring throughout the Great Lakes basin, it is likely that greater predatory pressure is being exerted on alewife populations than originally anticipated by fishery managers.

Managing the Fishery in a Changing Ecosystem

All of the above factors create an interesting paradox for fishery managers. The initial strategy was to manage predatory pressure on alewife populations by manipulating stocking levels of Pacific salmon. As Pacific salmon have become naturalized and the extent of natural reproduction is substantial, the ability of managers to control this strategy has decreased. Nevertheless, because of the contribution of alewife to thiamine deficiency complex (Honeyfield et al. 2005), a diet consisting largely of alewife reduces the success of natural reproduction of both Pacific salmon and native salmonids (S. B. Brown et al. 2005). Simultaneously, food web changes are occurring that appear to make the lakes less suited to production of alewife and Pacific salmon and more suited to production of several species of native fishes. As a result, the case can be made that it is logical for managers to direct fewer resources toward ac-
The management of Pacific salmon in favor of efforts to restore native species given these changing food webs. Conversely, the popular and economically important recreational fishery for Pacific salmon creates an atmosphere in which managers are pressured to maintain the Pacific salmon fishery at least at current levels. An important dilemma for managers to consider is whether to invest limited resources to sustain a popular sport fishery or to manage less intensively for natives fishes that may be better suited to the changing ecosystem.

In Lake Huron, this dilemma has already unfolded. In the space of 5 years between 2004 and 2008, the lake has gone from a system dominated by Chinook salmon and alewife to one in which alewife have been nearly eliminated and Chinook salmon harvest has been reduced from over 100,000 annually in 2003 to just over 3,000 in 2010 (Michigan Department of Natural Resources [DNR] 2011). This fundamental ecosystem shift apparently occurred because of (1) several years of stochastically low alewife recruitment; (2) the shift in food web structure toward more benthic production mediated by dreissenid mussels and Bythotrephes led to a reduced capacity for alewife to produce large year classes; and (3) natural production of Chinook salmon between 2000 and 2003 that could have been as great as 18 million annually (Johnson et al. 2010), which, coupled with annual stocking of 3.5 million Chinook salmon fingerlings, added substantial predation pressure on alewife in 2003 and 2004 (Michigan DNR 2011). As a result, the condition of Chinook salmon declined precipitously and mortality increased, as predicted by Goddard (2002). In response, management agencies reduced stocking of Chinook salmon by 50%, and angler effort and catch has declined by about 90%. In the absence of alewife, recruitment of native fishes, including lake trout (Riley et al. 2007), walleye (Sander vitreus; Fielder et al. 2007), cisco (Coregonus artedii), bloater, and emerald shiners (Notropis atherinoides; Schaeffer et al. 2008), is increasing. Thus, unwanted aquatic invasive species—such as dreissenid mussels and Bythotrephes—are changing the ecosystem from the state desired by anglers (i.e., a balance between Chinook salmon and alewife) to an alternative state where native species are dominant. Lake Huron fishery managers have adapted to this fundamental ecosystem shift and are managing the system primarily for native or naturally produced fishes. The state of Michigan decided in 2011 to further cut Chinook salmon stocking in Lake Huron (Michigan DNR 2011). Lakewide research demonstrated that about 80% of the Chinook salmon population is naturally produced (Johnson et al. 2010), and anglers recognize that stocked Chinook salmon are simply feeding existing predators, especially walleye and lake trout.

Interestingly, indications are that the ecosystems of Lakes Michigan and Ontario are also changing in ways that mimic the ecosystem changes occurring in Lake Huron during the early 2000s. Chinook salmon in Lake Michigan effectively reduce alewife abundance (Madenjian et al. 2002, 2005). The combination of results from Madenjian et al. (2002, 2005) and the Lake Huron experience suggests that sufficient numbers of Chinook salmon could be stocked to nearly eliminate alewife, especially in conjunction with a few years of stochastically low alewife recruitment. In turn, drastically reduced abundance of alewives could lead to the rehabilitation of populations of emerald shiner, lake trout, and cisco—native species that likely require further reduction of alewife than has already occurred in Lakes Michigan and Ontario (Bunnell et al. 2006; Madenjian et al. 2008) before they will recruit extensively.

As a result, managers on these lakes must now make the difficult decision about whether to

- manage for economic returns by balancing the demand for Pacific salmon fisheries with declining alewife production that supports these recreational fisheries; or
- manage for rehabilitation of native fishes previously suppressed by alewife.

Further complicating this picture are results from Lake Ontario that suggest that top-down processes are currently decoupled from bottom-up processes (Stewart et al. 2010). Although the decision choice for fishery managers may become moot following fundamental ecosystem shifts, it remains a significant paradox. It is not yet clear whether managers will strive to maintain the popular recreational Pacific salmon fishery and its associated economic benefit to the degree they have in the past. It appears to be increasingly difficult to balance between the predatory demand of Pacific salmon and alewife production in a constantly changing and unpredictable ecosystem. As a result, future management efforts may place more emphasis on the other aspects of fish community objectives that call for rehabilitating native fishes that have been at low levels for the past 50 years and that may regulate themselves in concert with the changing Great Lakes ecosystem.

ACKNOWLEDGMENTS

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Importance of Assessing Population-Level Impact of Catch-and-Release Mortality

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Many studies have measured the mortality of fish that are recreationally caught and released (i.e., catch-and-release [CR] mortality); however, little work has explored methods to understand the cumulative impact of CR mortality on fish stocks. Despite considerable examination of biological, ethical, and practical aspects of CR fisheries (Arlinghaus et al. 2007, 2012; Cooke and Schramm 2007), little research has evaluated the cumulative effects of the different sources of mortality on recreational fisheries. The purpose of this essay is to provide a brief discussion of the different components of mortality for fisheries with high rates of CR and the possible cumulative impacts of CR mortality on the quality of these fisheries. We demonstrate the need for studies that evaluate the impacts of CR mortality on fish stocks and estimate the fishing mortality rates associated with CR ($F_{cr}$).

Future research needs to move past estimating CR mortality to developing more intensive field studies to measure $F_{cr}$ for a wide range of fisheries.

COMPONENTS OF FISH MORTALITY

The instantaneous total mortality ($Z$) of a fished population is described by the equation

$$Z = F + M$$

where $F$ is the instantaneous fishing mortality and $M$ is the instantaneous natural mortality. Fishing mortality is the rate at which fish are removed from a population due to fishing. Natural mortality is the rate at which individuals are lost from a population due to natural causes (i.e., predation, senescence, or disease). Components of fishing mortality include harvest and deaths of fish that are caught and released (e.g., CR mortality from either immediate or delayed release of caught fish). To account for these components, the above equation can be expanded to

$$Z = F + F_{cr} + M$$

where $F$ is the instantaneous fishing mortality rate from harvest and $F_{cr}$ is the instantaneous fishing mortality rate via CR mortality. Fishing mortality from harvest is one of the most commonly estimated parameters in fisheries investigations via tagging studies, stock assessment models, and other approaches. It is important to make the distinction between $F_{cr}$ and CR mortality: $F_{cr}$ is the instantaneous fishing mortality rate resulting from CR mortality, whereas CR mortality is the proportion of individuals that die after being caught and released. Bartholomew and Bohnsack (2005) and Muoneke and Childress (1994) reviewed hundreds of published estimates of CR mortality, but we found no synthesis or literature reviews of $F_{cr}$ values. Relatively few studies have measured $F_{cr}$ for fish stocks.

For some stocks, $F_{cr}$ can be a significant source of mortality resulting from harvest regulations or behavior of anglers (e.g., voluntary release; Driscoll et al. 2007). Harvest regulations can cause $F_{cr}$ to be a substantial mortality source, particularly if the CR mortality rate is high and a large portion of the age structure is protected from harvest (Coggins et al. 2007). Even if CR mortality is not high, impacts can be substantial. For example, Florida’s common snook (Centropomus undecimalis) fisheries have been managed with increasingly stringent harvest regulations to prevent overfishing, which has increased release rates from 31% in 1981 to over 90% in the late 1990s (Muller and Taylor 2006). Common snook have relatively low CR mortality (approximately 3%), but due to increasing fishing effort, about 35% of the total fishery-related deaths are attributed to $F_{cr}$ (Muller and Taylor 2006). Many recreational fisheries (e.g., trout [Family: Salmonidae] or black bass [Micropterus spp.]) have high release rates of fish that are legal to harvest; thus, traditional measures of $F$ may not indicate the full impact of fishing on fish abundance, size, or age structure.

Although estimates of $F_{cr}$ are not common, this mortality source has not been completely ignored. Most marine and anadromous stock assessments incorporate indirect estimates of $F_{cr}$ by estimating the number of fish released in a fishery and multiplying this by an average CR mortality rate obtained from experimental studies. The resulting estimate of dead releases is then added to the catch to determine total fishing mortality in stock assessment models (i.e., $F_{cr} = F - M$). Similarly, Driscoll et al. (2007) used a tag-return study and a range of CR mortality rates from literature to understand the impact tournament...
fishing was having on a largemouth (*Micropterus salmoides*) fishery in Sam Rayburn Reservoir, Texas. The combined mortality associated with CR fishing (i.e., mortality of tournament released and fish immediately caught and released) accounted for 19–50% of the total fishing mortality.

**FUTURE RESEARCH AND MANAGEMENT NEEDS**

Future research needs to move past estimating CR mortality to developing more intensive field studies to measure $F_{cr}$ for a wide range of fisheries. In our experience, many fisheries professionals report CR mortality as if high values are harmful and low values are not a concern. However, the ultimate impact of CR on fish populations is known only through estimates of $F_{cr}$ because low CR mortality can have large population impacts (see common snook example above). Only by estimating $F_{cr}$ will we understand the impacts of CR mortality on fish stocks.

There are two basic options for estimating $F_{cr}$. First, applying literature-derived CR mortality rates in stock assessments or tag-return studies as per Driscoll et al. (2007) would provide estimates of $F_{cr}$. This may be the only feasible option for evaluating $F_{cr}$ for recreational fisheries that occur in the open ocean or on some of the larger inland lake and riverine systems. However, for many freshwater and estuarine fisheries a second method is possible. We suggest using a combination of telemetry and tag-return methods that have been shown to provide unbiased estimates of fishing and natural mortality rates (Pollock et al. 2004). In this framework, a fishery-dependent high-reward tag-return study is primarily used to estimate $F_{cr}$ whereas telemetry or fishery-independent tags are used to estimate $M$ (Pollock et al. 2004; Bacherel et al. 2009). Pollock et al. (2004) illustrated that combining the two tagging methods incorporated the advantages of both approaches and provided more precise estimates of $F_{cr}$ and $M$ than either method would individually. This design could be expanded to include additional mortality components if the fates of all caught telemetered fish are known. For example, tagging all telemetered fish with an additional external high-reward tag would allow researchers to document when fish are caught. If the fish is harvested it would contribute to $F_{cr}$ in the typical way. If the fish is released, then its survival could be monitored to estimate $F_{cr}$. This method also assumes a reporting rate of 100%, which is realistic due to the use of high reward tags. Nonreporting may still occur but it would be considered negligible. Although this method is not infallible (e.g., tag loss, incorrect fate determination, and tag failure), it is an improvement upon the resolution and uncertainty of conducting tag-return and telemetry studies independently (Pollock and Pine 2007).

Thus, we contend that future fisheries research should be directed less at estimating CR mortality where estimates exist under a range of environmental conditions for well-studied species (see examples in Cooke and Suski 2005). Instead, efforts should shift toward measuring $F_{cr}$, which could be compared to $F_{h}$ to understand whether $F_{cr}$ could be a significant component of total fishing mortality. Using this information, biologists could explore the population-level effects of both voluntary and regulatory release of fish. Managers could then incorporate this information into comprehensive management plans and future data collection needs to further reduce uncertainty in understanding stock status.

**ACKNOWLEDGMENTS**

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Due to travel restrictions by Federal agencies, the 142nd Annual Meeting of the American Fisheries Society might not have had quite as many attendees as at the Seattle meeting, but we still managed to have a strong showing with over 1,600 attendees, plus guests. Fisheries enthusiasts gathered in Minneapolis and Saint Paul, Minnesota to network with fellow fisheries professionals and students, to stay current on the latest in fisheries science, and to enjoy the sights and scenes of the Twin Cities and beyond. The AFS Minnesota Chapter partnered with the Minnesota Department of Natural Resources to make sure everyone had what was needed to keep the focus of the meeting – “Fisheries Networks: Building Ecological, Social and Professional Relationships” – on target, as well as to provide good cheer. (The weather was so pitch perfect, attendees began to wonder if the hosts had an “in” with the Big Guy.)

Initial registrants and continuing education seekers began arriving Saturday, when available training sessions included “Beginning/Intermediate GIS for Fisheries Biologists,” “Leadership At All Levels of AFS,” “Climate Change and Fish Habitat Project Workshop,” and other developmental topics. The first real treat came with the start of the conference proper on Sunday night’s Welcome Social. Festivities got off to a merry start at the Opening Social, held in the Great River Ballroom in the Crowne Plaza, overlooking a fantastic view of the Upper Mississippi. Guests hit the drink stations, snacked on shrimp, chicken skewers, cheese, and other hors d’oeuvres, and started up lively conversations with fellow attendees from the previous annual meeting in Seattle, as though there hadn’t even been a pause (much less a year!) between salutations.

The Plenary Session took place on Monday, with past president, Bill Fisher, calling the meeting to order, and our newly-elected president, John Boreman presenting the Distinguished Service Award to Andrew Loftus and the Carl R. Sullivan Fishery Conservation Award to the Alaska Salmon Program of the University of Washington.

Following the awards, the Plenary talks began with Dr. Villy Christensen, Professor at the UBC Fisheries Centre, the lead developer of the Ecopath with Ecosim approach and software (which is used extensively throughout the world for ecosystem-based management of marine areas), and the Director of the Nereus Program (a cooperative initiative of the Nippon Foundation and the Univ. of British Columbia, and a program named as one of the ten biggest scientific breakthroughs in NOAA’s 200-year history). His lecture on “Ecological Networks – From Who Did It to Future Food Webs,” began with lessons from experience with food web modeling, including how humans have impacted the oceans. He explained the importance of database-driven ecosystem model construction using global, spatial databases to parameterize, balance, and fit ecosystem models, and demonstrated some new approaches for science communication to the public. All of Christensen’s research comes down to trying to answer one question – “Will there be seafood and healthy oceans for future generations?” All signs point to a significant decrease in global fish supply if we continue down the same path we’ve been going.

The second plenary speaker, Dr. Barbara A. Knuth (Past-President of the American Fisheries Society) focused her
lecture on “Expanding the Reach of Fisheries Science and Management through Strategic Social Networking.” Dr. Knuth (who serves on the Ocean Studies Board of the National Research Council and on the NRC Committee on the Effects of the Deepwater Horizon Oil Spill on Ecosystem Services in the Gulf of Mexico; was Vice President of the Executive Board of the World Council of Fisheries Societies; and is a Vice Provost and Dean of the Graduate School at Cornell University and Professor of Natural Resource) does work with cutting edge resources that focus on the human dimensions of fisheries and wildlife management and policy, and is known particularly for her work on risk perception, communication, and management associated with chemical contaminants in fish. She’s not only informed, but continues to challenge others to understand the importance of social networks in fisheries management, explaining ways to cultivate these networks to help improve fisheries management capacity and foster positive relationships among stakeholders, managers, and scientists. Building strategies that will help stakeholders meet their different needs during a collaborative, community-based natural resource management project, is of great value to our science.

The third plenary speaker, Dr. William W. Taylor (another former president of AFS, and a University Distinguished Professor in Global Fisheries Systems in the Department of Fisheries and Wildlife at Michigan State University and a member of MSU’s Center for Systems Integration and Sustainability), gave his talk on “Fisheries Sustainability: The Science and Art of Coupling Human and Natural Systems.” Taylor is an internationally recognized expert in Great Lakes fisheries ecology, population dynamics, governance, and management, and he holds a U.S. Presidential appointment as a U.S. Commissioner (alternate) for the Great Lakes Fishery Commission. In addition, he has held a gubernatorial appointment to Michigan’s Aquatic Nuisance Species Coordinating Council, and a U.S. Secretary of Interior appointment to the Sport Fishing and Boating Partnership Council, which he chaired for eight years. He also is the associate director of the Michigan Sea Grant College Program. Taylor has an interest in environmental policy and management from a local to global perspective, and he believes that fish are the ultimate integrators, and are symbolic of our way of living harmoniously in the world. To understand their habitat, we must also understand how ours affects them. Fish habitat and fish production are directly linked to human systems locally and globally. Studying global change issues such as climate, evaluation of governance, policies on the impact of fish community dynamics and sustainability, is the first step to helping to obtain sustainability, and is key to developing effective policies for ecological and socioeconomic sustainability.

After the Plenary Session, students enjoyed their own conference-within-a-conference, starting with the Best Student Paper Colloquium followed by the Student-Mentor Social, whereby a panel of professional fishery scientists and aquatic ecologists from a range of backgrounds (including academia, state, and federal agencies, non-profit organizations, tribes, and industry) discussed the skills students needed to enter the Spawning Run. (photo: Jacob Osborne)
job market and be successful in the various sectors of fisheries management and science. After their talk, the panel members mingled with the students to offer advice and mentoring. Tuesday brought in the Best Student Judging along with the Best Student Paper-Poster Judges’ Luncheon (a yummy freebie!), followed by the Career Fair, where students showed up with their resumes to meet representatives from academic, state, federal, and non-government institutions to discuss employment opportunities. After a lot of excitement and work, students took the short walk from the conference center to the Eagle Street Grille for their Student Social, where brick walls, wooden booths, and blue leather topped chairs offered a perfect place to relax, eat zesty ribs, and take in a beer or two.

Another special group—the international conference-goers—joined together Tuesday when International Fisheries Section President Felipe Amezcua hosted an International Reception. Those in attendance enjoyed a Latin American menu (which really should be on everyone’s top buffet list at any AFS Annual Meeting). Amezcua always brings good talks and good food to the table at these events.

The Trade Show opened to booming business on Monday, and information-packed symposia could be found at every turn: “Understanding the Ecological and Social Constraints to Achieving Sustainable Fisheries Resource Policy and Management,” “Fisheries Data Dissemination – Building Better Networks,” “Stakeholder Involvement in Fisheries Science: New Approaches and New Partnerships,” “Climate and Fisheries: Responses of a Socio-Ecological System to Global Change,” and “Wildlife and Sport Fish Restoration 75th Anniversary,” to name just a few.

Wednesday called out for the athletically inclined (AFS’ own executive director, Gus Rassam, being one!) to conquer the 5k Spawning Run, which took place on a scenic trail along the Mississippi River on Harriet Island Regional Park in St. Paul. The Trade Show and Symposia continued throughout the day, and by afternoon almost 1,000 attendees and their guests were ready for the evening social: A Taste of Minnesota: The Famous and Infamous! A special Minnesota feast of walleye and lake herring (the “famous”), the jumping (and infamous) silver carp, complimented with a “Beer Extravaganza” featuring a dozen outstanding Midwestern microbreweries (also famous!) were available at multiple buffets, and even with so many attendees the lines were non-existent. For those who hadn’t had too much beer, Segway rides were offered. To culminate the 142nd Meeting, AFS members and the Arkansas Planning Committee gathered to network on riverboat cruises at the “Goodbye Twin Cities, Hello Little Rock” Social. After walking across the Wabasha Bridge, everyone set out on a 2-hour cruise through the wooded banks of the Mississippi River Gorge (the only true gorge on the Mississippi River), to relax with old friends, converse with new friends, finalize those new collaborative studies that were discussed at the previous night’s social, and eagerly talk about next year’s appropriate theme, “Preparing for the Challenges Ahead.”
The Governing Board. (photo: Brian Borkholder)

Minnesota Governor Mark Dayton speaks to the crowd. (photo: Brian Borkholder)

Les Douglas, owner of Creative Pewter Designs, looking to sell products to an AFS attendee. (photo: Coley Hughes)

Happy attendees at the Wednesday Night Social at the Nicollet Island Pavilion. (photo: Coley Hughes)

Folks making s’mores at the Nicollet Island Pavilion, Wednesday night’s “A Taste of Minnesota” Grand Social. (photo: Coley Hughes)

MN DNR Commissioner Tom Landwehr. (photo: Brian Borkholder)
A gentleman scanning through products of the new e-signage used for displaying posters. (photo: Jennifer Johnson)

Folks waiting to disembark from the paddleboats at the Thursday Night Social. (photo: Brian Borkholder)

A scene from the Trade Show Social on Monday night. (photo: Jennifer Johnson)

Two gentlemen enjoying the view of the Mississippi River at Wednesday night’s “A Taste of Minnesota” Grand Social. (photo: Cynthia Fox)

The Student Career Fair at the River Centre. (photo: Brian Borkholder)
The Arkansas Chapter of the American Fisheries Society is pleased to announce the third call for symposia, contributed oral, and contributed poster presentations for the 143rd Annual Meeting of the American Fisheries Society to be held in Little Rock, Arkansas! The meeting theme, "Preparing for the Challenges Ahead" is likely to stimulate thoughts and presentations on:

• Challenges facing natural resource agencies regarding mandates to do more with fewer resources
• Challenges facing educators regarding a growing knowledge base, changing student expectations, and teaching to Millennials
• Challenges facing students regarding their roles as future scientists and managers serving increasingly more diverse stakeholders
• Other challenges that confront fisheries and natural resource professionals

AFS 2013 will be 8-12 September in Little Rock, at the Statehouse Convention Center located at the east end of President Clinton Avenue. The River Market District in Little Rock and the Argenta District in North Little Rock offer the best in dining, entertainment, museums, and shopping. Let us show you some southern hospitality next year in Little Rock.

GENERAL INFORMATION
Fisheries and natural resource professionals are invited to submit symposia proposals or abstracts for contributed oral, poster, and speed presentations that address the meeting’s theme, or on other issues and subjects pertinent to our field. We encourage state and federal fisheries professionals, private biologists, academics, and students to participate. There will be four types of sessions at the meeting: Symposia (oral presentations organized by individuals or groups with a common interest), Contributed Oral Presentations (grouped together into themes), Contributed Poster Presentations (organized to coincide with either symposia or contributed oral presentations themes), and Speed Presentations for students or professionals just beginning research or interested in feedback on a specific issue.

A NEW TIME FORMAT
The Little Rock meeting will be experimenting with a new presentation time format. Regular symposia presentations and oral contributed presentations are designed to fit into 20 minute time slots. However, presenters should plan on presenting for 12 minutes, leaving 3 minutes for questions and 5 minutes for room changes (and further questions). It is important for symposia and oral contributed presenter to plan for, and abide by, this new time format.

SYMPOSIA
The Program Committee invites proposals for Symposia. We are specifically requesting topics related to the meeting theme of “Preparing for the Challenges Ahead.” Topics not addressing the meeting theme should be of general interest to AFS members. Symposia that address challenges facing broad groups of fisheries professionals, along with solutions to specific challenges will receive priority.

Symposium organizers are responsible for recruiting presenter, soliciting their abstracts, and directing them to submit their abstracts through the AFS online submission forms. Organizers are not required to recruit a full symposium at the time of proposal submissions. The Program Committee is particularly interested in working with symposium organizers to incorporate into symposia appropriate presentations that are submitted as contributed oral or poster presentations. A symposium should include a minimum of 10 presentations and we encourage organizers to limit their requests to 1-d symposia (about 20 oral presentations). Time slots are limited to 20 minutes, but multiple time slots (i.e., 40 or 60 minutes) may be offered to keynote symposia speakers.

Symposium proposals must be submitted by 11 January 2013. All symposium proposal submissions must be made using the AFS online symposium proposal submission form available on the AFS website (www.fisheries.org). The Program Committee will review all symposium proposals and notify organizers of their acceptance or refusal by 1 February 2013. If accepted, organizers must submit a complete list of all confirmed presentations and titles by 22 February 2013. Symposium presentation abstracts (in the same format as contributed oral or contributed poster presentation abstracts; see below) are due by 15 March
2013. All symposium presenters are expected to deliver PowerPoint presentations.

The Program Committee is developing ways to increase the accessibility of symposia to all potential participants. See future calls for papers, e-mail messages, and the meeting web site for more details.

FORMAT FOR SYMPOSIUM PROPOSALS
(submit using AFS online symposium submission form)
When submitting your abstract, include the following:

- Symposium title: Brief but descriptive
- Sponsors: If applicable, indicate sponsorship. Please note that a sponsor is not required.
- Organizer(s): Provide name, affiliation, telephone number, and e-mail address of each organizer. The first name entered will be the main contact person.
- Chairs: Supply name(s) of individual(s) who will chair the symposium.
- 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 meeting participants.
- 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. Please list special AV requirements.
- 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”).

The Program Committee invites abstracts for contributed oral presentations, contributed poster presentations, or speed presentations. Authors must indicate their preferred presentation format:

- Contributed oral presentation only,
- Contributed poster presentation only,
- Contributed oral presentation preferred, but poster presentation acceptable, or
- Speed Presentation

CONTRIBUTED ORAL AND POSTER PRESENTATIONS

Only one contributed oral presentation will be accepted for each senior author. Contributed oral presentations will be organized by 20 minute time slots (i.e., 12-minute presentation, 3 minutes for questions, and 5 minutes for room changes). All oral presenters are expected to deliver PowerPoint presentations.

We encourage poster submissions because of the limited time available for oral presentations. The program will include a dedicated poster session to encourage discussion between poster authors and attendees. The dedicated poster session will include traditional hard copy posters. In addition, the Program Committee is exploring methods for incorporating electronic posters, such as inclusion of electronic posters in symposia or other sponsored electronic poster opportunities.

SPEED PRESENTATIONS

The Program Committee is interested in organizing one or more speed presentation sessions. Speed presentations would require a brief (2-3 sentences) abstract submitted through the AFS abstract submission site. Speed presentations would be an outlet for students or professionals just beginning their research or interested in feedback on a small specific issue. The format for a speed presentation would be 1 or 2 PowerPoint slides used during a 3-minute presentation, followed by 2 minutes for questions or feedback.

STUDENT PRESENTERS

Student presenters must indicate if they wish their abstract to be considered for competition for a best student presentation (i.e., paper or poster, but not both) award by submitting to the Best Student Presentation competition section. If a student does not wish to be considered, they should submit to the normal contributed abstracts section. 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. Please note that speed presentations are not eligible for best student presentation.
Abstract Submissions

Abstracts for contributed oral and poster presentations and speed presentations may be submitted after 1 February 2013 and must be received by 15 March 2013. All submissions must be made using the AFS online abstract submission form, available at www.fisheries.org. When submitting your abstract:

- Use a brief but descriptive title, avoiding acronyms or scientific names in the title unless the common name is not widely known;
- List all authors, their affiliations, addresses, telephone numbers, and e-mail addresses; and
- Provide a summary of your findings and restrict your abstract to 200 words.
- Use 2-3 sentences for a speed presentation abstract.

All presenters will receive an email confirmation of their abstract submission and will be notified of acceptance and the designated time and place of their presentation by 5 April 2013. The Program Committee will group contributed oral and poster presentations thematically based on the title and two or three keywords you will choose and prioritize during the abstract submission process. Speed presentations will be combined into separate sessions.

Late submissions will not be accepted. AFS does not waive registration fees for presenters at symposia, workshops, or contributed oral or poster presentation sessions. All presenters and meeting attendees must pay registration fees. Registration forms will be available on the AFS website (www.fisheries.org) in May 2013. There is a cost savings for registering early.

Format for Abstracts

Title: An Example Abstract for the AFS 2013 Annual Meeting

Format: Oral

Authors: Lochmann, Steve. Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, 1200 N. University Dr., Pine Bluff, AR 71601; 870-575-8165; slochmann@uaex.edu

Racey, Christopher. Arkansas Game and Fish Commission, 2 Natural Resources Drive, Little Rock, AR 72205; 501-223-6371; clracey@agfc.state.ar.us

Presenter: Steve Lochmann

Abstract: Abstracts are used by the Program Committee to evaluate and select papers for inclusion in the scientific and technical sessions of the 2013 AFS Annual Meeting. An informative abstract contains a statement of the problem and its significance, study objectives, principle findings, and applications. The abstract conforms to the prescribed format. An abstract must be no more than 200 words in length.

Student presenter: No

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Steve Sammons, Auburn University, sammosm@auburn.edu, 334-844-4159
Aquatic science lost one of its most creative thinkers and astute administrators when Jim Sedell died on August 18, 2012. His scientific and management legacies were matched by the contagious enthusiasm he brought to the resolution of natural resource problems. To those who knew him, Jim was a whirlwind of energy, pulling in anything and everything in his path and sending it all skyward in a fountain of creativity.

Jim graduated from Willamette University and attended graduate school at the University of Pittsburgh, receiving a doctorate in biology and ecology. From 1971 to 1977 he held a research faculty position at Oregon State University, studying stream ecosystems in the H.J. Andrews Experimental Forest. Many of the insights gained from that work appeared in a co-authored 1980 paper—The River Continuum Concept—which crystallized a new paradigm of how energy and materials are recycled along gradients from small streams to large rivers. Jim also taught the importance of incorporating the history of an ecosystem in studying and managing it. The early work he and his students did on the Willamette and Coquille Rivers remains a key component of their management and rehabilitation. Knowing the fire, beaver, and splash dam history of PNW forests has led to changes in forest management, and that sense of history is also a large part of the reference condition concept used in the EU and by the USEPA and state water quality agencies for making ecological assessments, and in developing expected conditions for water bodies.

From 1977 to 1980 he managed an aquatic research team at the Weyerhaeuser Company. He immersed himself in applied science and pressed hard for changes in riparian protection on private industrial forests, loudly proclaiming the importance of large wood. Jim was instrumental in reversing the policy of removing trees from channels for fish passage to recruiting wood for fish habitat. So persuasive were his arguments that by the mid-1980s many management organizations formally recognized the importance of living and dead trees for fish habitat in their riparian prescriptions.

In 1980 Jim returned to Corvallis, Oregon, to lead an aquatic science team for the U.S. Forest Service Pacific Northwest Research Station. A few months later Mount St. Helens erupted. There was no way you could keep him from capitalizing on this unprecedented opportunity to examine ecosystem reassembly after a major disturbance. Jim was one of the first scientists to sample Spirit Lake and many of the new lakes formed by the largest recent volcanic landslide in North America. His studies at Mount St. Helens helped lay the groundwork for what has become one of the world’s most comprehensive collections of research on volcanic landscapes.

By the late 1980s it became clear that timber policies in the Pacific Northwest were not sustainable and confrontations grew between pro-development and conservation interests over federal timber sales. In 1989 a federal judge issued an injunction against 139 timber sales that brought the issue to a head. Congress appointed a panel of distinguished scientists—the “Gang of Four”—to develop a long-term management strategy that would protect essential functions of forest ecosystems while allowing for commodity production. The four panelists requested that Jim Sedell and Gordon Reeves join them because there was mounting evidence that anadromous salmonid populations were at risk. Together, they produced Alternatives for Management of Late-Successional Forests of the Pacific Northwest: A Report to the Agriculture Committee and the Merchant Marine and Fisheries Committee of the U.S. House of Representatives, a paper that remains one of the most important blueprints for managing forested watersheds in recent decades. The strategy for protecting anadromous fish habitat that eventually emerged from the effort was to become the conceptual backbone of many subsequent aquatic habitat conservation plans.

Although the report made quite a splash in the forestry community, Congress was unable to resolve the problem of reconciling timber production and ecosystem management. In 1993, following up on a campaign promise, President Clinton convened a Forest Summit in Portland, Oregon. Jim was selected to be the scientific expert for fish and water quality on the president’s panel and subsequently became coleader of the aquatic component of the Forest Ecosystem Management and Assessment Team. The new Northwest Forest Plan outlined an aquatic conservation strategy that was eventually implemented on Forest Service and Bureau of Land Management districts throughout the Pacific coastal ecoregion and has since been widely emulated.

After leading a similar effort to develop a broad aquatic conservation strategy for federal lands in the Interior Columbia River Basin, Jim accepted the position of Forest Service Water Coordinator in Washington, D.C. Soon thereafter he became Director of Wildlife, Fish, Water, and Air Research, a position that gave him an opportunity to provide scientific insights to policy makers at the national level. In 2004, Jim was appointed Director of the Pacific Southwest Research Station in Albany, California, where one of his favorite accomplishments was creating the Institute of Pacific Islands Forestry in Hilo, Hawaii, a...
center of research for management, preservation, and restoration of natural ecosystems throughout the Indo-Pacific.

Jim retired from the Forest Service in 2008 and took a position with the National Fish and Wildlife Foundation in Portland, Oregon. As Fish Conservation Director he was responsible for awarding and overseeing grants for protecting a variety of aquatic resources. It had always been Jim’s view that fish were part of larger aquatic communities and that effective conservation meant understanding how various parts interacted. Nevertheless, he understood the importance of fish to society and was proactive in supporting investigations of water flows and climate change on fish habitat, as well as research on species about which information was critically needed, such as Apache trout and the native fishes of the upper Klamath River basin.

Jim was able to share fresh ideas and insights from his work in the Pacific Northwest with foreign scientists. He spent a year at Environnement-Ville-Société du CNRS in Lyon, France, working with leading aquatic ecologists in Europe on dynamic processes in river systems. His international collaborations spanned a wide range of topics, from large-scale modeling of major floodplain rivers in Western Europe to the effects of introduced North American beaver on streams in Patagonia.

Although Jim left a rich and varied scientific legacy, he will be equally remembered for his ability to get people excited about science. He had an enthusiasm that, though at times exhausting for those around him, was always infectious. His sense of humor was legendary and as a cheerleader he was unequaled. Though he will be greatly missed by his colleagues, we can take comfort in knowing that our watersheds and the plants and animals they contain are better off for his having been here.

Pete Bisson, USDA Forest Service, PNW Research Station, Olympia, Washington;

Gordie Reeves, USDA Forest Service, PNW Research Station, Corvallis, Oregon;

Stan Gregory, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon
**The Untold Story of Bob Piper — AFS Honorary Member**

Jim Bowker  
U.S. Fish and Wildlife Service, Bozeman, MT.  
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Bob Piper was recently awarded honorary membership to our society. He had intended to attend the plenary session to personally accept this award and entertain us with a story about his introduction to the society. Unfortunately, Bob could not make the meeting to share this story with us. Not to be denied, here is his story (as told to U.S. Fish and Wildlife Service employee and American Fisheries Society member Jim Bowker).

My first encounter with the American Fisheries Society (AFS) was in my hometown of Rochester, New York, in 1951. The society was conducting its 81st Annual Meeting there, and I was home for the summer, having just completed my junior year at Cornell University. I was enrolled in Cornell with the goal to graduate with a bachelor of science degree in fisheries. So, when I read in the newspaper that the AFS was in town holding their meeting, I told my mom that I was going downtown to check it out and that I probably wouldn’t be home for supper. I hopped on a bus for the downtown Rochester Sheraton Hotel, where the meeting was being hosted.

Once there, I sauntered up to the registration desk in the hotel lobby and asked what it cost to attend the meeting. A nice lady behind the desk handed me a registration form, the meeting agenda, and some brochures and remarked that buses were about to leave for a tour of some state fisheries facilities and also for a visit to a local winery.

Of course, I had no intention of registering for the meeting because I was a dirt-poor college student. However, when I left the hotel, sure enough, there were folks boarding tour buses without any kind of ticket or boarding pass. I thought to myself “ah ha!” and began to mingle with the group, boarded the bus, and soon found that I was on my way, in the company of multiple members of AFS, for a day of touring.

It was a magnificent day and I had a great time; we stopped at a hatchery, had a free lunch, and were given a demonstration by David Haskell of an innovative backpack electroshocker for collecting fish in streams.

I spent the day eavesdropping on conversations between fisheries professionals and heard great stories about their various activities and their accomplishments. To a young neophyte fisheries student, it was an awesome experience.

The trip culminated with a visit to a New York winery where I observed the subtle transformation of a scholarly, soft-spoken group of scientists into a robust, song-singing band of colleagues enjoying each other’s friendship. I was impressed! I wanted to be one of them.

When I told my mom about my trip and meeting real fisheries scientists, she wasn’t so impressed—I think she smelled wine on my breath.

After graduating from college, I worked for several years at a commercial hatchery in Pennsylvania, paid off my modest (in those days) student loan, and joined the Fish and Wildlife Service in 1956. Finally, in 1958 I became a dues-paying member of the AFS.

The rest is history and I won’t bore you with the details because it could lead to a lengthy trilogy. I look fondly at my Golden Membership Award, presented to me in 2007, for a half-century of being part of AFS. I wish for all of you the same fantastic experience I’ve had—of a career filled with colleagues who became lasting best friends.

May each of you have the opportunity to enjoy a free bus tour in the company of a robust, song-singing band of colleagues enjoying each others’ friendship. Thank you for this special honor.
Needlefish

Jeff Schaeffer

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The image of the above fish is a Gyotaku¹ print by Harry S. Schaeffer of Key West, Florida, reflecting the actual image of a member of the Belonidae (needlefish) family. It was identified by the collector as a houndfish, but the image could represent one of several other species found in Florida waters. Needlefish have a circumtropical distribution. Houndfish are the largest Belonid and attain lengths of up to 1.5 m and weights of over 6 kg. Needlefish are predominantly nearshore species; they lurk near flats and reefs where they consume smaller fish by pursuit of up to speeds of 13 m/s that may involve long leaps. Needlefish have been studied infrequently, and most literature citations represent locality records or describe parasites. The few modern references that exist are found primarily in the medical literature and focus on houndfish, which have the unfortunate habit of impaling bathers and fishers during their prodigious leaps. Several reports have been written on the best way to remove them from swimmers. Fatalities due to houndfish impalement have been reported but remain unverified. However, these impalements can cause serious trauma. Two recent cases in Florida reported lung penetration and a serious neck injury (both victims recovered).

Needlefish are edible but have limited consumer appeal because they have green flesh and bones.

¹ "Gyotaku" is a Japanese technique in which an actual fish is inked and used as a printing block. The life-sized image may be enhanced by the artist, especially eye details. Gyotaku is thought to have originated in Japan as a way of recording size information during regional fishing contests, but it later became an art form. Gyotaku is difficult because the artist must manipulate delicate mulberry paper over a three-dimensional surface without tearing or smudges. Many printing attempts are spoiled before a high-quality image is attained.
Stoking the “Green Fire”1: Bringing the Land Ethic to the Water

John J. Piccolo

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Piccolo is an Associate Professor in the Biology Department at Karlstad University, Karlstad, Sweden. He’s worked in research and management of native fish in Alaska, Colorado, Idaho, Montana, Nevada, Wyoming, and Värmland, Sweden.

The 2011 American Fisheries Society (AFS) meeting in Seattle, Washington, was outstanding in many ways. It was the largest AFS meeting ever, with over 4,000 participants and 2,000 presentations. In my opinion it set a gold standard for disseminating a great volume of information to so many people. The ability to pre-upload presentations, use an online scheduling tool, and download the abstracts afterward allowed a tremendous amount of cutting-edge science and management information to be communicated to a record number of people. Thus, the meeting went a long way toward the goal of exploring its theme “New Frontiers in Fisheries Management and Ecology,” and it will indeed be remembered as “Leading the Way in a Changing World.” The conference organizers deserve much thanks for making the meeting such a success and for laying the foundation for future meetings in this new age of open-access information and rapidly advancing technologies.

This ability to communicate so much knowledge to so many people opens up new possibilities for making further progress on both new and existing frontiers. My intention in this essay is to address one such existing frontier—the development of a conservation ethic. This is not a new frontier in either ecology or ethics (e.g., Leopold 1949; Rolston 1975), but I believe that our progress in developing it has been too slow. In a recent Fisheries essay, Edwin “Phil” Pister expressed a similar sentiment (Pister 2011); he discussed over 50 years of California golden trout (Oncorhynchus mykiss aquabonita) conservation, concluding that “there is a growing need … for an improved environmental ethic …” and that “the role of public education in preservation of species cannot be overemphasized” (see also Pister [1993] for a thoughtful essay on conservation ethics). I couldn’t agree more, and as we look toward ever larger audiences and enhanced communication, I believe that the American Fisheries Society can play a key role in extending this important frontier.

I begin by recalling Aldo Leopold’s sentiment, “that land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics” (Leopold 1949:viii). This statement addresses an important fundamental shift from “is” questions, which describe ecosystems (what Leopold termed communities), to “ought” questions, which guide moral behavior (Rolston 1975). I contend that although ecologists are rapidly improving our ability to address is questions, we have become increasingly isolated from the ethical underpinnings as to why we ought to conserve species and ecosystems. This is particularly true during the period since the environmental movement of the 1960s–1970s, because this period happens to coincide with rapid technological advances in scientific methods, analyses, and communication. Although this period resulted in a legal mandate to conserve species and their ecosystems (e.g., the Endangered Species Act), it has been

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1 “Green Fire” is taken from Aldo Leopold’s famous quote about the shooting of a wolf in his essay “Thinking like a mountain.” It is the title of a new documentary film about his life and work (www.greenfiremovie.com).
suggest that it is largely through science that modern society is driven by both rapid scientific advances (which have not been communicated to managers with equal expediency) and by the ever-increasing pressures that modern society imposes on ecosystems.

Although we have continued to make progress in conservation, no ecologist, manager, or layperson should be deceived as to the short- and long-term threats to freshwater and marine ecosystems worldwide. The most recent compilation of imperiled freshwater fish, by the AFS Endangered Species Committee, for example, stated that “imperilment of inland fishes has increased substantially … [since 1989]” (Jelks et al. 2008). If the problems at home are not enough, glance over the recent International Union for Conservation of Nature reports on freshwater biodiversity in Africa and Europe (www.iucn.org) or read up on the impending threats to the Mekong River ecosystem (www.mekonginfo.org/). In regards to marine ecosystems, many AFS members are probably aware of the ongoing debate on deep-sea fishing, which made national headlines during the 2011 meeting (Seattle Times 2011). Although there may be some room for debate concerning how acute the overfishing crisis is and what proportion of species is affected, it is certain that direct human impacts are great and increasing. Indirect human-driven impacts, such as climate change and ocean acidification, will exacerbate or exceed these threats to freshwater and marine ecosystems. But my intention here is not a gloom-and-doom letter—rather, it is a call to action, precipitated not only by these increasing threats but by what I see as a new opportunity to meet them.

Among his many insights into the impending environmental crisis, Aldo Leopold was particularly critical of both consumerism and the loss of wilderness through mechanized travel; the former because it removed people from nature and the latter because it diminished the chances to reconnect with nature. It was during his time in New Mexico in the 1920s that Leopold realized the importance of roadless “wilderness” and the effects that mechanized travel were about to have on wild places. This led to his successful effort to lead the creation of America’s first wilderness area. But even with his unique insight I wonder whether Leopold could possibly have imagined the subsequent explosion in mechanized travel and mass consumerism that defines modern global society. His conclusion that “Nothing could be more salutary at this stage than a little healthy contempt for a plethora of material blessings” is now more relevant than ever before. It seems to me that along with the right to avail ourselves of technological advances to improve the pace and scope of scientific research, scientists have the responsibility to lead the way toward a better definition of society’s relationship with nature. Aldo Leopold saw modern society’s detachment from nature as the major impediment to the evolution of a land ethic. If this is true, then we have a lot of work ahead of us, given how our society has developed since his death in 1948. This is why I

In my opinion, failure to overtly address the ought question in conservation has resulted in the scientific community—and the public at large—being less certain (and therefore less supportive) of conservation measures. I propose that revisiting Leopold’s land ethic offers a meaningful way of addressing this ought question. I further contend that conservation, like any scientific endeavor, requires this theoretical underpinning to achieve its full potential. Yes, I know, science is supposed to be objective—dealing with is questions that address patterns in nature and (hopefully) their underlying processes. But I agree with Leopold (1949), Rolston (1975), and numerous others who have suggested that it is largely through science that modern society has gained the understanding that ecosystem services are the basis for sustaining life. Hence, if sustaining life is considered morally right, then science is already addressing the imperative ought question in conservation. The immediacy of bringing this fundamental shift from is to ought to the forefront, however, is juxtaposed with increasingly quantitative and complicated analyses; for example, measures of genetic diversity, critical habitat, and ecosystem services. Thus, a species and its critical habitat (its ecosystem) is to be legally protected only when quantitative analyses can demonstrate, within some predetermined P value, that it is genetically unique and at risk of extinction. Wiens (2008) elegantly pointed out, however, the difficulties of rectifying this level of scientific rigor with the day-to-day realities of pressing conservation decision making. In general, the 2011 AFS meeting was typical in that the is questions in conservation received a great deal of attention, whereas the ought was barely mentioned (the word “conservation” appears on virtually every one of the 1,686 pages of downloaded abstracts but I could find conservation ethics addressed in only three abstracts).

feel such urgency in bringing the topic to the forefront of issues to be addressed by the world’s foremost professional fisheries society.

Like Leopold and many others who have subsequently addressed a land ethic, I have no simple formula for how this is to be done (but see Piccolo [2011] for a discussion relevant to salmonid conservation). For many who profess to have developed a land ethic, scientific learning has been a key factor. For me, it was only after studying both science and environmental ethics that I saw where these paths meet. One way forward, therefore, might be to redouble our efforts at communicating science to the public and improving science education in schools. Symposia at future AFS meetings that specifically address conservation ethics may be a good first step. But beyond education, perhaps we all have some level of inherent “biophilia,” as E. O. Wilson suggested, which requires contact with nature to be stimulated. For myself, I can clearly trace my first stirrings of a land ethic back to the time I received an aquarium at the age of five. Robert J. Behnke related a similar story about catching his first trout (Behnke 2002), an experience that has led to a lifetime of conservation of native fish. His most influential work has arguably been the popular science column in the Trout Unlimited’s quarterly magazine, which has educated a generation of anglers about native trout (Behnke 2007). More than classrooms and textbooks, therefore, I suppose that it is contact with nature that has the greatest potential to stimulate and strengthen one’s land ethic. Hence, successful conservation efforts are themselves feedback loops that provide opportunities for future generations to develop relationships with “things natural, wild, and free” (Leopold 1949:ix).

I have had the good fortune throughout my career to work with people who are renowned worldwide for ecology, conservation, and environmental ethics. Many of them are cited here. This article is really just a synthesis of their ideas—standing in the footprints of giants, if not on their shoulders. I began my career as a fisheries manager, after which I spent some time immersed in theoretical ecology before returning to applied ecology and conservation science. Theoreticians address *is* questions in the purest sense, in the timeless human quest to explain patterns we find in nature. In the same way, philosophers since Leopold have sought the underlying ethic for conservation. Their conclusions have ranged from purely utilitarian values of nature to an acceptance of inherent natural value (see Callicott 1999). Leopold (1949:224) would appear to have been firmly in the latter camp when he wrote his most famous lines: “A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.” Be that as it may, philosophers will never have P values to extol, so the true center of value, whether in nature or as a construct of the human mind, shall forever remain, as Leopold (1949:ix) acknowledged, “subject to the blurs and distortions of personal experience and personal bias.” Having broadened my research from theoretical to applied ecology again, I now find nothing incongruous about addressing the *ought* question that underlies conservation. In fact, I see it more and more as a necessary underpinning of the work, and I fear that in the long-term, conservation programs that don’t do so are destined to fail.

Ecologists search for patterns and processes that we hope will allow us to contribute to sustainable management of Earth’s ecosystems. Science can and should lead the way in answering these important *is* questions. But despite our ever-increasing proficiency, I fear that science alone will not achieve answers fast enough to prevent further catastrophic ecological degradation. The variation inherent in natural systems, in fact, will always preclude our ability to predict ecosystem responses with 100% accuracy, no matter how sophisticated our models become.

Ultimately, we may find that the only process common to all ecosystems is simply the interconnectivity of all of their components, including ourselves. In that case it may be only the land ethic that unites them, and it may be that sustainability can only be achieved by recognizing and addressing this.

**ACKNOWLEDGMENTS**

Thanks to all of the professors, students, colleagues, and naturalists from all walks of life who have contributed to these ideas over the years. E. Pister and one anonymous reviewer provided helpful comments.

**REFERENCES**


**JOURNAL HIGHLIGHTS**

**Transactions of the American Fisheries Society**

**Volume 141, Number 5, September 2012**

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**Dam Removal Increases American Eel Abundance in Distant Headwater Streams.** Nathanial P. Hitt, Sheila Eyler, and John E. B. Wofford. 141: 1171–1179.


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A Bit of History

The Night I Disrupted a Danish Airliner Schedule

Mervin F. Roberts
Retired Fish Biologist, Old Lyme, CT. E-mail: ritzeb@99main.com

In the mid-1960s I was dabbling in aquarium fishes, and my then-boss, Dr. Herbert R. Axelrod, sent me to Denmark on some related business. A final task on that trip was to visit Colonel Jorgen Scheel to pick up some African cyprinodonts for Dr. Axelrod. The colonel had collected them in the Congo and was breeding them in his Copenhagen home.

On the eve of my scheduled departure from Denmark I was to be the guest of the colonel and his wife. I arrived in time for dinner and it was delicious. Then there were sweets and cigars—and the ticking clock. The evening festivities were going longer than planned. I began to imagine the airport announcer calling the number of my flight, when the colonel eventually set out to show me his extensive collection of rare African Fundulus and other killifishes. There was a lot to see, but finally the colonel netted the various pairs of fishes for Dr. Axelrod and put them in thermos jars. Still, all I could envision was the airplane on the taxiway that was aimed at America—and I wasn’t on it. Add to the long evening a leisurely goodbye drink of aquavit, and I was already making plans to get a hotel for the night and another flight the next day.

In due course, the colonel and his wife bid me a fond farewell and only then did I see, pulled up to his front porch, a sedan with Danish Army markings on it. A soldier jumped out, took my luggage, helped me in, and we took off for the airport. We drove to a guarded gate, which two soldiers promptly opened, and we drove right across the airport runways to a lighted plane with its loading ramp down and its cabin door open. The other passengers were already settled in. Soldiers helped me on board with my luggage. No luggage was checked. No one ever asked to see what was in my thermos jars or my ticket or visa or passport; I was not frisked or X-rayed; I didn’t even take off my shoes. The soldiers just helped me board the plane, saluted, and departed.

The aircraft door closed as a stewardess showed me to my seat and the plane immediately took off, delayed by about a half an hour.

I later mentioned the colonel’s name and was told that he was not only a Danish colonel but he (or his wife) was also a member of the Danish Royal Family. The plane quickly made up the half-hour delay and I got home on schedule. And that’s the way it was with ichthyology back in the good old days.

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and reevaluating the AFS financial model, paying particular attention to the income from activities versus the costs of maintaining those activities and their benefits to membership and the fisheries profession as a whole.

Finally, the governing board tackled the third and fourth radical changes: rigorously defining the current and potential member and product markets and rationalizing programs and services. The board members recognized that professional society memberships and member needs are changing over time, and it is difficult to judge what programs and services AFS should be providing in the future. Surveys of AFS members and unit leaders have consistently shown the value of our publications and meetings as key methods of communicating our science as well as with one another. The retreat attendees agreed that we have not ascertained what our potential membership base could be or what member markets we are not satisfying. Additionally, we need more effective mechanisms to reach out to potential members, and we have not evaluated the utility of our current or potential programs and services. Maybe our current scope of benefits does not resonate with younger and older professionals and retirees. Suggestions made at the retreat to help address these issues included mining our own membership data and doing a better job of tracking hits on our website to determine the potential for expanding our membership; marketing our publications, meetings, continuing education courses, and other services more effectively; doing more to promote and describe the value of fisheries as a profession; providing regular testimonials in our published materials and website; and surveying individuals who do not renew their memberships to determine key causal factors.

The issues and solutions discussed at the governing board retreat are starting us out on a road to greater success and relevance of AFS as a professional society. As I mentioned in my closing remarks at the retreat, a turtle cannot make progress without sticking out its neck.

**REFERENCE**


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**From the Archives**

What we want is a pure river and river bed; this latter we can hardly expect for some time under any circumstances, as there is a very great and dense mass of filth in the river, but, if all unite, north and west, and without petty considerations of self interests, and without any spirit of Bumbledom, we may have it at last.

Fred Mather (1875): Poisoning and Obstructing the Waters, Transactions of the American Fisheries Society, 4:1, 14-19.
CALENDAR
Fisheries Events

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

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

More events listed at www.fisheries.org

<table>
<thead>
<tr>
<th>DATE</th>
<th>EVENT</th>
<th>LOCATION</th>
<th>WEBSITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 4–5, 2012</td>
<td>13th Flatfish Biology Conference</td>
<td>Westerbook, CT</td>
<td><a href="http://mi.nefsc.noaa.gov/flatfishbiology-workshop">http://mi.nefsc.noaa.gov/flatfishbiology-workshop</a></td>
</tr>
<tr>
<td>January 22–24, 2013</td>
<td>Georgia Chapter of the AFS Annual Meeting</td>
<td>Jekyll Island, GA</td>
<td><a href="http://www.gaafs.org">www.gaafs.org</a></td>
</tr>
<tr>
<td>March 26–29, 2013</td>
<td>Responses of Arctic Marine Ecosystems to Climate Change Symposium</td>
<td>Anchorage, AK</td>
<td>seagrant.uaf.edu/conferences/2013/wakefield-arctic-ecosystems/index.php</td>
</tr>
<tr>
<td>April 8–12, 2013</td>
<td>7th International Fisheries Observer and Monitoring Conference (7th IFOMC)</td>
<td>Viña del Mar, Chile</td>
<td><a href="http://www.ifomc.com/">www.ifomc.com/</a></td>
</tr>
<tr>
<td>April 15–18, 2013</td>
<td>Western Division of the AFS Annual Meeting</td>
<td>Boise, ID</td>
<td><a href="http://www.idahoafs.org/meeting.php">www.idahoafs.org/meeting.php</a></td>
</tr>
<tr>
<td>July 14–20, 2013</td>
<td>2nd International Conference on Fish Telemetry</td>
<td>Grahamstown, South Africa</td>
<td>Contact: Dr. Paul Cowley at <a href="mailto:tagfish@gmail.com">tagfish@gmail.com</a></td>
</tr>
</tbody>
</table>

TELEMETRY TECHNIQUES
A USER GUIDE FOR FISHERIES RESEARCH

Edited by
Noah S. Adams
John W. Beeman
and John H. Eiler

Telemetry provides a powerful and flexible tool for studying fish and other aquatic animals, and its use has become increasingly commonplace. However, telemetry is gear intensive and typically requires more specialized knowledge and training than many other field techniques. As with other scientific methods, collecting good data is dependent on an understanding of the underlying principles behind the approach, knowing how to use the equipment and techniques properly, and recognizing what to do with the data collected.

This book provides a road map for using telemetry to study aquatic animals, and provides the basic information needed to plan, implement, and conduct a telemetry study under field conditions. Topics include acoustic or radio telemetry study design, tag implantation techniques, radio and acoustic telemetry principles and case studies, and data management and analysis.

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

518 pages
List price: $79.00
AFS Member price: $55.00
Item Number: 550.68C
Published September 2012
Fisheries Biologist / Lake Management
Solitude Lake Management, HQ in VA
Permanent

Salary: Commensurate with qualifications and experience
Closing: Until filled

Responsibilities: Growing professional services firm dedicated to preservation and restoration of fresh water resources is seeking qualified candidates to support our growth in the Lake Management services we offer. Candidates will be expected to perform all field work required to support our lake and fisheries management services, to include pesticide applications for the treatment and control of invasive aquatic vegetation, algae, and other water quality issues through the application of aquatic herbicides, installation of fountains and aeration systems, and application of other water quality restoration products to maintain a healthy aquatic ecosystem. Candidates will also assist our fisheries management division with fish stocking, fish surveys and populations assessments, habitat management, water quality monitoring, and other related fisheries services.

Qualifications: Qualified candidates should be able to demonstrate and document previous experience in this field and will be expected to become a licensed aquatic pesticide applicator for the states in which they will work.

Contact: Kevin Tucker, by below email or by phone 1-888-480-5253
Email: ktucker@solitudelake.com
Link: http://www.solitudelakemanagement.com

Computer Programmer/Data Analyst
Quantitative Fisheries Center, MI State Univ
Professional

Salary: $45,000–$50,000
Closing: Until filled

Responsibilities: Utilize fisheries and computer programming knowledge and skills to provide modeling and analytical support for Quantitative Fisheries Center scientists, staff, and supporting partners. Develop and support use of decision analysis models. Provide statistical data analysis support to center scientists and staff; assist with preparation of funding proposals, reports and scientific manuscripts. Responsible for computer system maintenance including server maintenance, data backup, security procedures, and web development.

Qualifications: Master’s degree in Fisheries Science, Ecology, Scientific Computing or related field. Minimum of 3 years full-time experience in fisheries research with extensive emphasis in computer programming, data analysis, and simulation modeling. Familiarity with C++, VB.net, R, and/or AD Model Builder is desired.

Contact: Applicants must apply for this position via the link https://jobs.msu.edu using posting number 6832. Applications must include letter of interest, CV, description of relevant experience, expertise, and professional goals, and names and contact information for 3 references.
Email: brenden@msu.edu
Link: http://qfc.fw.msu.edu

Regional Fisheries Management Biologist
WY Game and Fish Dept
Permanent

Salary: $4,569.00–$5,375.00 per month
Closing: Until filled

Responsibilities: Conserve and enhance the aquatic resources of northwest Wyoming, including waters in the Big Horn, Yellowstone and Shoshone River drainages. Additional details available at https://statejobs.state.wy.us/JobSearchDetail.aspx?ID=20678

Qualifications: Prefer Master’s degree in fishery biology, biology, zoology, ichthyology, wildlife management, or closely related field, PLUS two years of professional work experience in fisheries management, aquatic resource research or aquatic habitat management.

Contact: Preference will be given to applicants who submit a cover letter to Mr. Dave Zafft, Fisheries Management Coordinator, 528 S. Adams St., Laramie, WY 82070 (FAX 307-745-8720, or below email), in addition to submitting the state application.
Email: david.zafft@wyo.gov
Link: https://statejobs.state.wy.us/JobSearchDetail.aspx?ID=20678

North Pacific Groundfish Field Coordinator
AIS, Inc.
Permanent

Salary: Commensurate with experience and includes benefits package
Closing: 12/1

Responsibilities: AIS, Inc. Positions located in ports along the Gulf of Alaska and the Bering Sea. The Field Coordinators will be the primary source of direction and support for the observers working for the partial coverage portion of the NPGOP. Interact with industry and support observers throughout their geographic area and complete sampling trips as needed. Travel throughout Alaska may be required depending on the coordinators assigned area.

Qualifications: A BS in Marine Biology or other natural science is required including 30 credits of biological course work and 5 credits of mathematics. Previous observer experience or sea and fish research experience preferred. Experience managing people, providing logistical support and strong organizational skills, experience with MS Office and a valid driver’s license are required.

Contact: Jay Litchfield at below email.
Email: jay@aisobservers.com
Link: http://goo.gl/JHWa9
Manager – Salmon Hatchery
Prince William Sound Aquaculture Corporation, AK
Permanent

Salary: DOE. Benefit package includes private housing, medical insurance, generous annual leave accrual, travel and relocation assistance.

Closing: Until filled

Responsibilities: Year-round hatchery manager position in Prince William Sound. The hatchery manager works closely with the General Manager to coordinate all aspects of facility operations, supervision of personnel, administrative duties and construction.

Qualifications: BS in Fisheries or related field and/or Business Administration.

3 years experience managing a production facility and supervising staff.
Working knowledge of salmon culture techniques.
Working knowledge of accounting and budgeting.
Excellent written and verbal communication skills.
Must be able to live in a remote environment.

Contact: See www.pwsac.com for online application. Submit completed application, resume and cover letter to email address below.

Email: cece.pwsac@ak.net

Watershed Scientist
Versar, Inc., Columbia MD
Permanent

Closing: Until filled

Responsibilities: May include fieldwork/ team leadership, field equipment management, task management, writing assignments, data compilation and quality control for Storm runoff monitoring projects
Stream geomorphic, benthic and fish surveys
Illicit discharge detection and elimination
Upland watershed assessments using Center for Watershed Protection methods

Qualifications: BS Environmental Science or equivalent

Experience with:
Electronic flow monitoring
Automated sampling using ISCO equipment
Stream velocity measurements using flowmeter and wading rod
Fluvial geomorphic assessment (Rosgen or equivalent training is preferred)
Benthic sampling using methods comparable to Maryland Biological Stream Survey (MBSS)
Fish sampling using backpack electroshocker
ArcGIS

Contact: Information may be found at our corporate web site (www.versar.com) and our Mid-Atlantic regional office site (www.esm.versar.com). Submit resume through Versar’s corporate web site (www.versar.com) “Careers” page, Position 2012-1465.

Modeler/Biometrician
Cramer Fish Sciences; Auburn, CA
Permanent

Salary: $5,265 – $6,046 monthly, plus bonuses; excellent benefits

Closing: Until filled

Responsibilities: CFS seeks an individual with very strong quantitative and programming skills. Expertise in developing and analyzing individual/agent based models using NetLogo or other modeling platforms is highly desirable. Knowledge and experience with other statistical analyses, programming languages, and with ecology and resource management is a plus. Must be able to collaborate with biologists to develop simulation models and quantitative assessments for ecological data.

Qualifications: Ph.D. or M.S. with one or more years of experience with simulation modeling and statistics. Strong technical writing and advanced computer skills. Experience leading small to moderate sized projects. Highly-motivated, self-starter who can work independently and as part of a team. Speak and write English fluently.

Contact: E-mail cover letter and resume to below email Full job announcement at: www.fishsciences.net

Email: hr@fishsciences.net

Natural Resource Specialist II TO3264 ESA
Santa Rosa, CA
Permanent

Salary: $22.17/hr

Closing: Until filled

Responsibilities: Natural Resource Specialist II TO3264 ESA section 7 Consultation Assistance

Ocean Associates is seeking a Natural Resource Specialist II to support the NOAA NMFS Southwest Region Habitat Conservation Division. Review and evaluate proposed projects and applications submitted to NMFS pursuant to section 7 of the Endangered Species Act (ESA). Evaluate and analyze effects of proposed actions, conservation measures, and mitigation activities on ESA-listed salmon, steelhead and green sturgeon and their habitat. Develop recommendations on ways to minimize adverse effects to ESA-listed fish and their habitat associated with proposed activities. See web site for additional responsibilities.

Qualifications: BS degree in fisheries, biological sciences or natural resource management and 3 years of experience, or a MS degree and one year of experience. Knowledge of anadromous fish life history, biology, and habitat requirements. See web site for additional qualifications required.

Email: jobs@oceanassoc.com

Link:
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CALL FOR PROPOSALS  GREAT LAKES FISHERY

Pre-proposals for the 2014 funding cycle for the Great Lakes Fishery Commission’s (GLFC) Fishery Research Program and Sea Lamprey Research Program are now being solicited.

**Pre-proposals are due January 15, 2013**

Awards are generally between $50,000 and $150,000/year. Pre-proposals will be evaluated against the information needs described by each program’s Research Themes (see below).

FISHERY RESEARCH PROGRAM

Research Themes for the Fishery Research Program
- Fish Health and Ecosystem Dysfunction
- Human Dimensions
- Physical Processes and Fish Recruitment in Large Lakes
- Restoration of Native Deepwater Fishes
- Research priorities identified by fishery managers

Areas of Special Interest
- Ecological and socio-cultural impediments to native fish restoration
- Cumulative effects of ecosystem-level processes and stressors on fish communities
COMMISSION RESEARCH PROGRAMS

More information about these Research Programs and this call for pre-proposals is available on the GLFC website:

http://www.glfc.org/research

SEA LAMPREY RESEARCH PROGRAM

Research Themes for the Sea Lamprey Research Program
- Barriers and Trapping
- Lampricides
- Assessment
- Chemosensory Communication Systems

Areas of Special Interest
- Natal origins of parasitic sea lamprey (e.g., statolith microchemistry)
- Improved trapping using sea lamprey behavior and ecology
- Lampricide treatment variables that result in residual sea lamprey populations
- Importance of parasite-host interactions at the fish community level
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