Fisheries

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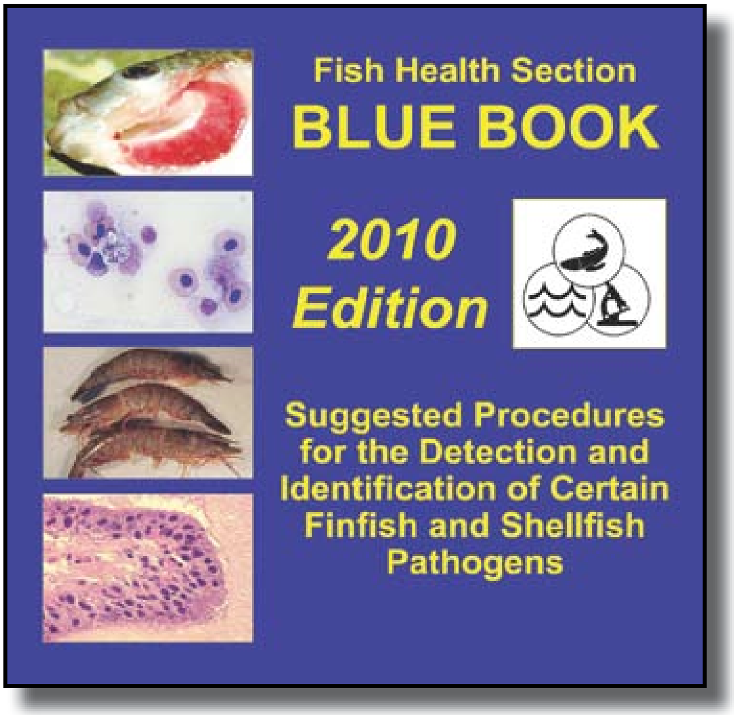
Similarities, Differences, and Unknowns in Biology and Management of Three Parasitic Lampreys of North America

Tagging by Lobster Fishermen to Estimate Abundance of the Discarded Portions of Their Catch



Fish Health Section
BLUE BOOK
2010 Edition
Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens

VOL 35 NO 12
DECEMBER 2010

Fisheries

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

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AFS journal publishing moves into a new era

Starting with the first issues of 2011, AFS will begin publishing all of its journals using a partnership with the well-renowned, major commercial publisher, Taylor and Francis.

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COVER: Great Lakes sea lamprey, *Petromyzon marinus.*
PHOTO: Ulrich Reinhardt.

**COLUMN:
PRESIDENT'S HOOK**

Wayne A. Hubert
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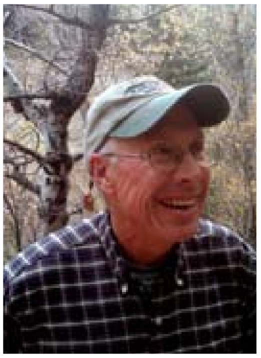

New Frontiers in Fisheries Management and Ecology: AFS Leadership in Policy

It was a bright and sunny October day that demanded some time outdoors. I was visiting my son and his family in Sheridan, Wyoming, and my son and I decided to slip out for a little trout fishing on a small stream in the nearby Bighorn Mountains. The stream flows through a steep-walled canyon with cascades tumbling over huge boulders and occasional deep pools where brightly-colored rainbow trout lurk. You have to be part mountain goat and a little crazy to attempt to fish the stream. I decided to use an ultralight spinning rod and spinners that afternoon. After climbing down the canyon wall to a pool that had to hold some trout, I made my first cast. It went entirely across the pool and the spinner caught on a piece of vegetation poking out of a rock cliff. I was miffed and gave the rod a swift jerk. That freed the spinner, and it came flying toward me like a bullet. I turned my head in self defense, but could not avoid the projectile. The result was an ornament attached to my ear by two of the three treble hooks. That spoiled a nice afternoon of fishing and resulted in a trip to an urgent care facility, and I had only myself to blame.

In the aftermath of that escapade, I asked myself why I did what I did. I told myself, "You should have stopped to think. You should have thought about the possible ramifications of your actions. You should figure out what you will do the next time you get hung up on a branch. You need a policy."

The following Monday morning I was still thinking about policy, stimulated by a little pain in my right ear. When I got to my office I was confronted by needed work as we moved forward on a couple of proposed AFS policy statements, Climate Change and Fisheries, and Lead in Sport Fishing Tackle (draft policy statements as well as policy statements passed by a vote of the membership, and background documents can be found on the AFS website: www.fisheries.org.). AFS policy statements are published documents, developed and approved by AFS members, that express an analysis of the science regarding an issue and guidance on policy or courses of action regarding the issue. That morning I was struck by just how valuable AFS policy statements can be.

Do you know that AFS has 33 formal policy statements? The most recent Climate Change Policy Statement was approved in November 2010. They cover an amazing spectrum of issues from Nonpoint Source Pollution and Toxic Substances, to Transgenic Fishes and Ballast Water, to Special Fishing Regulations and Responsible Use of Fish. Take a gander at the AFS website for the full array of titles and policy statements. It is a remarkable list addressing many, many issues that fisheries managers, decision makers, policy makers, law makers, and voting citizens may confront.

The policy statements carry strong scientific credibility because of the rigorous procedures for their development (see the *AFS Procedures Manual* on the website). The process for development is guided by the AFS Resource Policy Committee (RPC). This committee is composed of a Chair, Vice-Chair, and nine members appointed by the President with staggered terms. The AFS Executive Director, editor of *Fisheries*, and Policy and Development Coordinator serve as nonvoting members. Any formal AFS unit, informal group, or individual member can propose an issue for study and development of a policy statement. The RPC Chair requests comments from the RPC and knowledgeable AFS members in regard to the importance of the issue to AFS members, potential significance to aquatic recourses, and possible overlap with existing AFS policy statements. If deemed appropriate, the AFS President forms a work group in consultation with the RPC Chair and sponsor to develop a study report that provides information to determine if a formal policy statement is needed. The work group includes AFS members knowledgeable on the issue. If the study report indicates that a formal AFS policy may be appropriate, a work group is appointed by the President in consultation with the RPC Chair and sponsor to prepare a draft. A draft is subsequently submitted to the RPC Chair who solicits reviews and comments from RPC members, knowledgeable AFS members, and AFS units likely to have interest or expertise related to the issue. Reviews include technical, editorial, political, social, and economic considerations. The work group and RPC Chair may revise the draft using guidance provided by reviewers. The next step is for the RPC to recommend the draft policy statement to the AFS Governing Board for action. If a majority of Governing Board members approve the draft, it is presented to the AFS membership for review and comment. The draft is posted to the AFS website and notice is sent to all members by electronic mail in addition to a notice in Fisheries directing members to review the draft and send comments to the AFS

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Greetings from AFS Headquarters

AFS End-of-Year Book Sale

AFS is offering many publications at reduced prices. From now until January 15, 2011, take advantage of our End-of-Year Book sale and save on selected titles. Complete your science library at dramatically reduced prices – all sale publications are priced from $5.00 to $20.00. No refunds or returns on this special offer. These sale books are available through our online bookstore only. Details at: www.afsbooks.org

If you're looking for a unique, perfect, holiday gift, how about a membership for a newcomer at half price?

You will not only surprise that special someone, but will also have your name added to our recruiter's list, with a chance to win a special prices in August. This gift membership is a $40 value that keeps on giving. Why an AFS membership as a gift?

1. you know someone who lives overseas without a way to make international purchases.
2. you know someone who has difficulty accessing the Internet.
3. you know someone who can't do a wire transfer.
4. you know someone who is about to show up at your doorstep with a gift for you, and now you need a gift, fast. An AFS membership is a perfect last-minute gift!

To order your half-price gift, send an email to: membership@fisheries.org. You'll then be instructed as to how to have your personalized message to that special somebody sent from AFS and you.

We'd like to remind our chapters, divisions, and sections to keep us updated on any news you might have to share.

We often publish your Unit news in the pages of Fisheries. The information we're most interested in sharing with our members is:

1. announcements of special events or meetings.
2. updates on projects in which you are engaged.
3. any awards won.
4. any new photos of unit special events (we'd love to start posting photos of members in action and engaged at events).

Send news and photos to:
sgilbertfox@fisheries.org

We wish you the best for the
holidays and the new year to come.
Thank you for your service to the Society!

JOURNAL HIGHLIGHTS: NORTH AMERICAN JOURNAL OF FISHERIES MANAGEMENT

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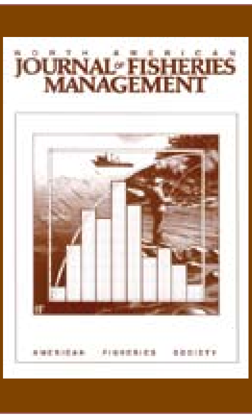
October 2010



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UPDATE: LEGISLATION AND POLICY

Elden Hawkes, Jr.

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AFS Presents Briefing On BP Oil Spill

The American Fisheries Society held a briefing entitled "Science Perspectives on the British Petroleum Oil Spill in the Gulf of Mexico" during its 140th annual meeting, held in Pittsburgh, PA. The briefing featured representatives from both federal and state agencies that are directly involved with the day to day response to the oil spill and its lingering effects. Speakers included Steve Murawski (NOAA NMFS), Dan Ashe (USFWS), John Epifanio (USGS), and Brian Alford (Louisiana Dept of Wildlife and Fisheries).

The complete video of the briefing can be found on the American Fisheries Societies website at www.fisheries.org/afs/docs/fisheries/fisheries_3508.pdf.

A Canadian Fishery Is Certified As Sustainable

After having met the Marine Stewardship Council (MSC) standard for sustainable management, the Ocean Choice International (OCI) Grand Bank Yellowtail Flounder Trawl Fishery has earned Marine Stewardship Council (MSC) certification.

The final assessment report cited both strengths and weaknesses for the fishery. The strengths include a comprehensive monitoring and surveillance system; considerable data about the stock; security of access that provides a strong economic incentive to manage for the long term; and an effective management strategy for the endangered wolffish. The weaknesses include a need for the development of well-defined harvest control rules, and improvements in the stakeholder consultation process.

The annual quota established by North American Fisheries Organization was 17,000 metric tons in 2009 and 2010, and the Canadian allocation is 97.5 per cent. OCI is the holder of the largest allocation of the Canadian Total Allowable Catch (TAC) with 91.4 per cent. The remaining 8.6 per cent is held by five other companies.

NOAA Releases National Catch Share Policy

The National Oceanographic and Atmospheric Administration has released a national catch share policy that includes limited access privilege programs and individual fishing quotas. The policy is designed to encourage the consideration and use of catch shares as a fishery management tool aimed at rebuilding fisheries. According to NOAA, the use of catch shares is helping eliminate overfishing and achieve annual catch limits worldwide. They have also been seen to improve fishermen's safety and profits, and reduce the negative biological and economic effects of the race for fish that develops with some traditional fishery management.

As a result of the policy, catch shares will be used in 14 fisheries managed by six fishery management councils from Alaska to Florida, and are being developed in additional fisheries.

As part of the policy, NOAA added several guiding principles, including a recommendation that regional fishery management councils periodically revisit allocations between commercial and recreational sectors in fisheries.

NOAA officials say councils will have the agency's support to consider catch share programs for charter boat and head boat sectors to explore recreational catch share pools that could benefit the health of the resource and the charter industry. However, the policy does not advocate individual catch shares for private recreational anglers.

More information on the policy and profiles of catch share programs can be found at http://www.nmfs.noaa.gov/catchshares.

Aquaculture Amendment Bill Introduced into New Zealand Parliament

The Aquaculture Legislation Amendment Bill was recently introduced the New Zealand Parliament, to amend the legislative and regulatory framework of aquaculture within the country, and to ultimately encourage its aquaculture growth.

The bill would streamline the planning and consenting processes which would reduce costs to industry, and it would provide stronger incentives for industry development. These measures could put aquaculture in New Zealand on pace to becoming a $1 billion industry by 2025.

The bill is designed to help regional councils manage high or competing demand for space within the coastal marine area, and to enable central government to take a more active role in aquaculture planning and consenting. The bill also removes the requirement for Aquaculture Management Areas. This step is designed to provide a more integrated approach in the needs of aquaculture.

The official text of the Aquaculture Legislation Amendment Bill can be found at www.legislation.govt.nz/bill/government/2010/0239/latest/contents.html

Iceland Rejects Proposed Mackerel Quota

Iceland recently rejected a mackerel quota proposed by the European Union and Norway. The rejected proposal would have increased Iceland's quota of the mackerel to 26,000 tons. This is 2,000 tons higher than the previous quota. The proposed quota from the EU comes as reaction to the unilateral raising of the mackerel quota to 130,000 by Iceland earlier this year.

The European-Norwegian proposal corresponds to 3.1 percent of the total European quota, against 16 percent if Iceland fished 130,000 tons. The international environmental group WWF has warned that the unilateral quotas set by Iceland and the Faroe Islands (which recently tripled its quota to 85,000 tons) could mean a "death sentence" for the fish. Negotiations on the quotas are due to continue.

FEATURE:
FISHERIES MANAGEMENT

Similarities, Differences, and Unknowns in Biology and Management of Three Parasitic Lampreys of North America

ABSTRACT: Sea lampreys, *Petromyzon marinus*, are invasive to the Laurentian Great Lakes where they have decimated native fishes. Great Lakes sea lampreys have been subjected to control measures for several decades, and the drive to control them has led to major advances in understanding their biology and in informing management. In contrast, anadromous sea and Pacific (*Entosphenus tridentatus*) lampreys have co-evolved with their oceanic prey. Both of these anadromous lampreys are in decline, and a limited amount of information on their biology has stymied conservation. The tendency has been to make biological inferences about anadromous lampreys based on the Great Lakes sea lamprey without justifiable evidence. We identify areas in which key information is missing for the juvenile (parasitic feeding) phase and adult freshwater spawning migrations, and compare and contrast information for these lampreys. Our comparisons reveal major differences, some intriguing similarities, and key unknowns that will require empirical testing.

Similitudes, diferencias e incógnitas en la biología y manejo de tres lampreas parásitas en los Estados Unidos de Norteamérica

RESUMEN: la lamprea marina, *Petromyzon marinus*, es una especie invasiva de la región de los grandes lagos de los Estados Unidos de Norteamérica, en los cuales han diezmado las poblaciones de peces nativos. La lamprea marina de los grandes lagos ha sido sujeto de medidas de control por varias décadas y esta necesidad ha dado lugar a importantes avances en el entendimiento de su biología y manejo. En contraste, la lamprea anádroma y la del Pacífico (*Entosphenus tridentatus*) han co-evolucionado con sus presas oceánicas. Actualmente las poblaciones de ambas lampreas se encuentran en declive y la escasez de información sobre su biología ha interferido con su conservación. La tendencia ha sido hacer, sin evidencia que lo justifique, inferencias acerca de la lamprea del Pacífico sobre la base de lo que se conoce de la lamprea de los grandes lagos. Se identificaron áreas en las que se carece de información crítica de la fase juvenil (alimentación parasitaria) y de las migraciones reproductivas de los adultos y se comparó y contrastó información para estas lampreas. La comparación reveló diferencias significativas, algunas similitudes interesantes e interrogantes clave que demandarán de comprobación empírica.

Benjamin J. Clemens, Thomas R. Binder, Margaret F. Docker, Mary L. Moser, and Stacia A. Sower

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INTRODUCTION

Eleven parasitic lamprey species have been described in North America (Nelson et al. 2004), including the largest and most managed, the anadromous sea and Pacific lampreys (*Petromyzon marinus* and *Entosphenus tridentatus*, respectively), and the invasive sea lamprey (*P. marinus*) of the Laurentian Great Lakes. The remaining nine parasitic lamprey species have more restricted distributions, are generally smaller in body size (Nelson et al. 2004; Renaud et al. 2009), and are not actively managed to the same extent that sea and Pacific lampreys are. This review compares the biology and management of the anadromous and Great Lakes sea lampreys and the Pacific lamprey (Table 1).

The establishment of invasive sea lampreys in the upper Great Lakes by the mid-1940s was a major impetus for the creation of the Great Lakes Fishery Commission (GLFC). The GLFC initiated an international coordination and collaboration of research on the Great Lakes sea lamprey (Fetterolf 1980), which has led to a control program that has been called "…one of the largest and most intensive efforts to control a vertebrate predator ever attempted" (Smith 1980).

No organization similar to the GLFC exists to promote the conservation and management of native anadromous sea and Pacific lampreys across American and Canadian boundaries (although a conservation initiative has recently been designed for the Pacific lamprey, e.g., see Luzier et al. 2009). As a consequence, information on these anadromous lampreys is less extensive (Table 2), and managers have used the extensive published information on the invasive Great Lakes sea lamprey to infer the biology of anadromous sea and Pacific lampreys.

Such interferences may hinder research on anadromous lampreys and can result in flawed management. The goals of this paper are to: 1) compare and contrast the biology of the well-studied Great Lakes sea lamprey with that of the anadromous sea and Pacific lampreys of North America; 2) identify areas in which key information is missing; and 3) determine the extent to which information from the Great Lakes sea lamprey can be applied to the conservation of anadromous sea and Pacific lampreys. We begin with a brief examination of taxonomy, distribution, and the life cycle of these lampreys, and then focus on their juvenile (parasitic feeding) phase, upstream migration, and spawning. We then briefly examine differences in habitats and selection pressures experienced by each of these lampreys, and conclude with lessons learned from our comparisons.

TAXONOMY AND DISTRIBUTION

The sea lamprey in North America consists of two forms: the adfluvial sea lamprey in the Great Lakes, and the anadromous form that occurs along the Atlantic seaboard (Figure 1). In contrast, the Pacific lamprey likely consists of only an anadromous form (Figure 1). All three of these lampreys are parasitic and semelparous, but each display different geographic distributions (Figure 2; Hubbs and Potter 1971; Scott and Crossman 1973) and belong to divergent taxa. The genera *Petromyzon* and *Entosphenus* both belong in the single family of northern hemisphere lampreys—Petromyzontidae—but morphological characters suggest that *Petromyzon* is one of the most ancestral lamprey genera, whereas *Entosphenus* is one of the more derived (Gill et al. 2003). Based on degree of mitochondrial DNA divergence, these genera are estimated to have diverged at least 9–13 million years ago (Docker et al. 1999). The American Fisheries Society Common and Scientific Names of Fishes supported synonymizing *Entosphenus* with *Lampetra* (Nelson et al. 2004), but the AFS Names of Fishes Committee is currently reviewing their decision and is expected to recognize *Entosphenus* as a valid genus (J. Nelson, University of Alberta, 2007 pers. comm.). At least five other *Entosphenus* species have been described in addition to the Pacific lamprey, whereas the sea lamprey is the sole species in its genus (Nelson et al. 2004).

The anadromous sea lamprey is native on both sides of the North Atlantic Ocean, from Labrador to the Gulf of Mexico in

Table 1. Summary of the status and threats to lampreys, benefits to humans, estimated ecosystem services, and management practices.

	Great Lakes sea lamprey	**Anadromous sea lamprey**	**Anadromous Pacific lamprey**
Invasive or native?	Invasive nuisance species[a]	Native	Native
Population trends	Variable[b]	Declining	Declining rapidly; petitioned to be listed under the ESA
Threats	Not applicable	Pollution, habitat degradation, obstacles to spawning habitat (dams)	Similar to anadromous sea lamprey
Benefits to humans	None realized	Scientific study	Food and ceremony for Native Americans[c]
Co-evolved with prey base?	No[a]	Yes	Yes
Estimated ecosystem services	Recycle stream nutrients and introduce lake-derived nutrients to watersheds; negatively impact native fish stocks	Recycle stream nutrients; introduce marine-derived nutrients to watersheds; salmonids[c] food source for freshwater, estuarine and marine animal	Similar to anadromous sea lamprey; predation buffer for native and endangered
Management practices	Control via larvicides, sterile male releases, man-made barriers to spawning grounds, and capture and removal of adults fish stocks	Creation of fishways to allow adults to pass dams	Modification of fishways to allow adults to pass dams; transplanting of adults to tributaries[d]

[a] Genetic evidence suggest that the Lake Ontario population is indigenous, but this issue is not resolved (see text)

[b] Population at or near target levels over last 10 years in Lake Ontario but numbers have generally been increasing in Lake Michigan (Larson et al. 2003; Lavis et al. 2003)

[c] Close et al. 2002

[d] Close et al. 2009

Table 2. Relative level of information available (None, Low, Moderate or High) for Great Lakes sea lamprey and anadromous sea and Pacific lampreys. Many of the references are comprehensive reviews of relevant studies, and citations provided here are not exhaustive.

Area of biology	Great Lakes sea lamprey	Anadromous sea lamprey	Anadromous Pacific lamprey	References
Survey, collection, and handling techniques	High	Low–Moderate	Low–Moderate	Moser et al. 2007
Basic biology (life history, feeding, reproduction)	High	Moderate	Low–Moderate	Applegate 1950; Scott and Crossman 1973; Docker 2006; SLIS 1, 2
Management	High	Low–Moderate	Low–Moderate	Kostow 2002; Moser and Close 2003; SLIS 1, 2
Abundance estimates of parasitic phase adults; bioenergetics and host impacts	High	None	None	SLIS 1, 2; Docker 2006
Upstream migration characteristics and swimming capacity	High	Moderate	Moderate	Moser and Mesa 2009; Reinhardt et al. 2009
Migration pheromone	High	None	Low	Sorensen and Hoye 2007; Robinson et al. 2009
Spawning pheromone	High	None	Moderate	Li et al. 2003, 2007; Johnson et al. 2009
Biology of maturation and spawning	High	Moderate to High	Low	Hardisty and Potter 1971; Scott and Crossman 1973; Beamish and Potter 1975; Sower 2003; Docker 2006; Mesa et al. 2010
Identification of reproductive hormones and receptors	High	High	Where known, likely similar to the other lampreys	Sower 2003; Silver et al. 2004; Freamat and Sower 2008; Kavanaugh et al. 2008; Sower et al. 2009; Bryan et al. 2006, 2008
Endocrine profiles during holding, migration, maturation and spawning	High	High	Moderate	Sower 1990; Bolduc and Sower 1992; Sower 2003; Sower et al. Submitted

the western Atlantic, and from northern Norway to the western Mediterranean in the northeast Atlantic (Hubbs and Potter 1971). Landlocked sea lamprey populations occur in the Great Lakes basin and other inland lakes in New York State and Vermont (Figure 2; Kraft et al. 2006). Landlocked sea lampreys are considered invasive within the Great Lakes; with the completion of the Welland Canal in 1820, they were able to bypass Niagara Falls and spread throughout the Great Lakes by 1946 (Smith 1971). Recent genetic evidence supports a natural post-Pleistocene colonization of Lake Ontario (Waldman et al. 2004, 2009; Bryan et al. 2005), but this conclusion is not universally accepted (see Eshenroder 2009) and the sea lamprey is still considered non-native in Lake Ontario for conservation and management purposes (Renaud et al. 2009). The Pacific lamprey occurs in oceanic waters and coastal rivers in Asia from Siberia to northern Japan, and in North America from the Aleutian Islands, Alaska, to Baja California, Mexico (Figure 2; Renaud 2008), and they are native throughout their range.

LIFE CYCLE

The Great Lakes sea lamprey has been well-studied in comparison with anadromous sea and Pacific lampreys (Table 2). The commonalities of their life cycle are as follows: sea and Pacific lampreys develop as endogenous-feeding embryos (Piavis 1971; Meeuwig et al. 2005) before spending 3–8 years as filter-feeding larvae (ammocoetes) in soft stream sediments (Scott and Crossman 1973). During the late summer and early fall, a number of exogenous and endogenous signals cue transformation of the ammocoetes into macrophthalmia with functional eyes, sharp teeth, and silver body

Figure 1. Anadromous Pacific lamprey (top), anadromous (sea run) sea lamprey (middle), and Great Lakes sea lamprey (bottom) of North America. The illustration depicts the relative differences in body size among these three lampreys. (Illustration: Deian Moore)

coloration (Youson 2003). Macrophthalmia become entrained in the water column during freshets and appear to emigrate in a passive fashion (Applegate 1950; van de Wetering 1998) to the lake or ocean where they parasitize hosts. After 1–4 years (see below), they cease feeding and migrate back into freshwater streams to spawn and then die (F. W. H. Beamish 1980a; R. J. Beamish 1980).

In the following sections we compare and contrast two phases during which the biology of these three lampreys appears to differ: 1) the juvenile (parasitic feeding) phase; and 2) the adult (upstream migrating and spawning) phase. Where necessary, we supplement the information for anadromous sea lampreys of North America with information from anadromous sea lampreys from Europe.

Juvenile—parasitic phase

Juvenile anadromous sea and Pacific lampreys occasionally parasitize fish in fresh water during emigration from rearing areas to lakes or the ocean. Salmonids and clupeids appear to be common hosts of sea lampreys in freshwater systems entering the Atlantic Ocean (Potter and Beamish 1977; F. W. H. Beamish 1980a), and emigrating salmon smolts are not uncommon hosts of juvenile Pacific lamprey in the Columbia—Snake River system, some 630 river kilometers from the ocean (Setter et al. 2004). Freshwater parasitism en route to the ocean may be a function of long migratory distances (Hardisty and Potter 1971), perhaps providing transport or a replenishing source for low lipid reserves before entering the ocean (Potter and Beamish 1977). Some researchers have hypothesized that this feeding behavior can lead to adaptation to freshwater environments (Potter and Beamish 1977) or preparation for osmoregulation in sea water by sea lampreys (Hardisty and Potter 1971; F. W. H. Beamish 1980b).

The ability of parasitic sea lampreys to reside in fresh water appears to be a function of origin and body size: anadromous sea lampreys osmoregulate better in sea water than Great Lakes sea lampreys, and large-bodied Great Lakes sea lampreys can osmoregulate better in sea water than small-bodied Great Lakes sea lampreys, likely a result of a smaller body-surface-to-volume ratio (F. W. H. Beamish 1980b). Therefore, colonization of the Great Lakes may have involved selection for small body size and changes in osmoregulatory abilities (F. W. H. Beamish 1980b).

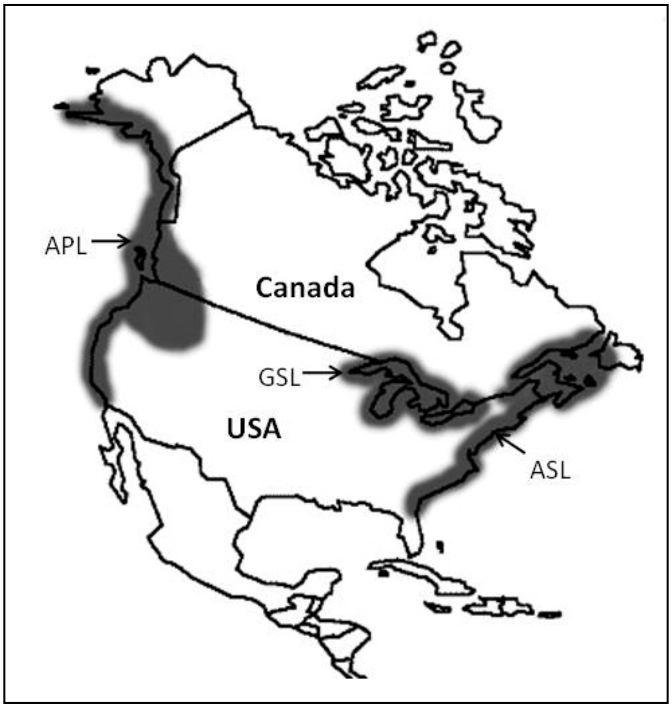
In contrast to the sea lamprey, several studies suggest that parasitic-phase Pacific lampreys cannot thrive in fresh water. Pacific lamprey populations have become extirpated after they were disconnected from the ocean through river impoundment (e.g., see Wallace and Ball 1979; Beamish and Northcote 1989), and juvenile Pacific lampreys held in the laboratory in fresh water fed poorly and ultimately died (Clarke and Beamish 1988). Populations of freshwater-resident Pacific lamprey have been reported (e.g., Moyle et al. 2009) but none are formally recognized. Some populations of lacustrine, non-migrating forms once considered to be dwarf races of Pacific lamprey have been elevated to species status (e.g., Bond and Kan 1973; Beamish 1982), and others (e.g., the Goose Lake population of Oregon) likely deserve species status (Moyle et al. 2009). Of the six described *Entosphenus* species, all but the Pacific lamprey occur solely in fresh water (Nelson et al. 2004). The lineage and taxonomy of these freshwater lampreys deserves further study, as the Pacific lamprey may speciate rapidly in fresh water.

The ocean phase of Pacific lampreys is estimated to be ~3.5 years, although this duration may only apply to moderate to large (250–500 mm) fish. Smaller returning adults probably have a parasitic phase < 3.5 years (R. J. Beamish 1980). Sea lampreys along the Atlantic seaboard likely spend ~2 years in the marine phase (23–28 months; F. W. H. Beamish 1980a), whereas sea lampreys in the Great Lakes generally have a shorter parasitic phase (12–20 months; Applegate 1950). The growth rate during the parasitic phase has been estimated at 0.65–0.79 g/day for sea lampreys in the Western Atlantic (F. W. H. Beamish 1980a) and 0.89 g/day for Great Lakes sea lampreys (Applegate 1950). Growth rate data are lacking for Pacific lampreys.

Sea and Pacific lampreys have similar attachment sites on host fishes, the majority of scars being ventrally- and anteriorly-located (reviewed in Cochran 1986). Adult salmon and adult gadiiforms, in addition to a wide assortment of other commercially and ecologically important fishes, have been reported as hosts for both anadromous sea and Pacific lampreys (F. W. H. Beamish 1980a; R. J. Beamish 1980). In addition to fishes, various marine mammals have been reported as hosts for the Pacific lamprey (reviewed in Scott and Crossman 1973 and R. J. Beamish 1980), and parasitism of basking sharks (*Cetorhinus maximus*) by anadromous sea lampreys has also been observed (Wilkie et al. 2004). The Great Lakes sea lamprey feeds on a number of freshwater fish species, such as lake trout (*Salvelinus namaycush*), rainbow trout (*Oncorhynchus mykiss*), *Coregonus* spp., yellow perch (*Perca flavescens*), channel catfish (*Ictalurus punctatus*), carp (*Cyrinus carpio*), and others (Scott and Crossman 1973).

The degree of parasite-induced mortality in the ocean remains unknown, and such estimates require knowledge of abundance and host preferences for anadromous sea and Pacific lampreys. Parasite-induced mortality has been characterized in the Great Lakes (e.g., see Harvey et al. 2008; Madenjian et al. 2008; Table 2), and the large information base for Great Lakes sea lampreys allows modeling of bioenergetics and estimates of effects on host populations (e.g., see review by Docker 2006 and more recent work by Madenjian

Figure 2. Distribution of anadromous Pacific lamprey (APL), Great Lakes sea lamprey (GSL) and anadromous sea lamprey (ASL) in North America.



et al. 2008). Within the Great Lakes, the sea lamprey has decimated populations of indigenous fishes, although this appears not to have occurred in their natural range (Smith 1971). Likewise, no host decimations have been reported (since human observation of native lampreys began) for the Pacific lamprey or other parasitic lampreys, suggesting potential co-evolution of these parasitic lampreys with their hosts (Potter and Beamish 1977).

The comparisons we have made for the juvenile—parasitic life stage have revealed a surprising lack of detailed biological knowledge for anadromous sea and Pacific lampreys, particularly the degree of parasite-induced mortality in the ocean. More empirical data for growth rates and duration of this life stage is needed for anadromous sea and Pacific lampreys. It is also not known whether potential differences in feeding localities in the ocean might reveal differences in prey types, duration of parasitic feeding, and growth rates that might be greater within a species than between anadromous sea and Pacific lampreys. Finally, should differences in the biological characteristics of the parasitic life stage exist between anadromous sea and Pacific lampreys, such differences might be the result of differences in ecosystem health, stability, and productivity between the Atlantic and Pacific Oceans. Nevertheless, use of telemetry to track lampreys in the open ocean, in conjunction with tissue collection for stable isotope and proximate analyses, could provide information on geographical distributions, bioenergetic budgets, trophic niches, and host impacts.

Adult—non-feeding phase

Orientation and homing

At the end of the parasitic phase, sea and Pacific lampreys cease feeding and initiate their upstream migration (Scott and Crossman 1973). Research on returning Great Lakes sea lampreys suggests that they orient to a larval (migratory) pheromone, which leads them to streams with quality spawning and rearing habitat (Sorensen and Hoye 2007; Wagner et al. 2009). The pheromone appears to work in concert with other factors, such as rheotaxis (Vrieze et al. 2010) and temperature (Binder and McDonald 2008) to control upstream migration by the lampreys to their spawning grounds. The sea lamprey migratory pheromone is composed of at least three separate bile acid compounds (Sorensen et al. 2005). The migratory pheromone does not appear to be species-specific (Fine et al. 2004), and a similar pheromone system exists in the Pacific lamprey (Robinson et al. 2009). However, Pacific lampreys seem to have a longer period of sensitivity to the major lamprey bile acids. Control of the Great Lakes sea lamprey has recently employed use of these pheromones to attract and trap upstream migrants (Wagner et al. 2006), and the pheromones may also be useful for attracting Pacific lampreys to suitable spawning habitat (Robinson et al. 2009).

A mark-recapture study found that Great Lakes sea lamprey returning to streams to spawn randomly distributed themselves among tributaries instead of returning solely to their natal streams (Bergstedt and Seelye 1995). Radio-tracking of displaced adult Pacific lampreys likewise suggests a lack of homing (Hatch and Whiteaker 2009), albeit with a much smaller sample size and over a relatively short study period (< 163 days) for fish that spend ≥1 year in fresh water prior to spawning (see "Overview and Timing of Upstream Migration," below).

Genetic evidence likewise suggests that anadromous sea lampreys do not home to their natal streams. A relative homogeneity in microsatellite markers suggests panmixia along the Atlantic coast of North America (Bryan et al. 2005), although both mitochondrial (Rodríguez-Muñoz et al. 2004) and microsatellite (Bryan et al. 2005) markers show a lack of genetic exchange between North American and European sea lampreys. Within the Great Lakes, significant genetic differentiation was observed between sea lampreys in the lower versus the upper Great Lakes, but genetic differences among tributaries within a lake were observed only in Lake Erie. This may have been due to a lack of homogenous spawning habitat in and among tributaries rather than a result of homing (Bryan et al. 2005).

Do anadromous Pacific lamprey exhibit some sort of stock structure, whether it be homing to natal streams or via some other mechanism? The answer to this question is unresolved, due to the seemingly contradictory results of two separate studies that used different genetic tools and different collection methods. Although mitochondrial DNA markers have provided no evidence of population structure for Pacific lamprey ammocoetes collected from coastal streams from southern British Columbia to central California (Goodman et al. 2008), amplified fragment length polymorphisms (AFLPs) have provided evidence of weak stock structure in adults of this species from Japan, Alaska, the Pacific Northwest, and within the Pacific Northwest (Lin et al. 2008). It is unclear whether the lack of agreement between studies is a function of different genetic techniques and/or different sampling methods. Other genetic tools, such as microsatellite markers, may be necessary to delineate more nuanced genetic variability that might exist.

Native American tribes in the Pacific Northwest have collected Pacific lampreys from sources in the lower Columbia River Basin and transplanted these fish into formerly inhabited rivers in the hopes of reestablishing stocks (Close et al. 2009). The success of these efforts is contingent upon reproductive success of the fish and a continued return of spawners to these rivers, but whether lamprey would return through natal homing or attraction to larval pheromones remains unknown.

Overview and timing of upstream migration

The upstream migration can be divided into three phases, using a slightly modified terminology from Robinson and Bayer (2005): 1) the initial migration; 2) pre-spawning holding; and 3) final migration/spawning. The duration and location of each of these phases often among the three lampreys (see Figure 3). Pacific lampreys generally spend ~1 year in fresh water before spawning (R. J. Beamish 1980; Chase 2001), but can reside in fresh water for as long as 2 years (Whyte et al. 1993; D. Hatch, Columbia River Inter-Tribal Fish Commission, 2007 pers. comm.). In contrast, Great Lakes and anadromous sea lampreys do not initiate upstream migration until ~4 months before they spawn, and they reside in the fluvial fan of the river mouth or estuary prior to entering the river (Applegate 1950; Figure 3). Although it is not known what proximate and ultimate factors have been selected for such a prolonged freshwater residency in Pacific lampreys, we hypothesize that it may be a function of the larger river systems on the west coast compared to those in the Great Lakes or along the Atlantic seaboard.

In the Pacific Northwest, sexually immature Pacific lampreys cease feeding and enter fresh water during April–June in the year prior to spawning (R. J. Beamish 1980), and begin their initial migration during July–September (Scott and Crossman 1973; Robinson and Bayer 2005). Pacific lampreys hide under stones while overwintering during October–March (Scott and Crossman 1973) before their final migration, nesting and spawning during April–July, after which they die (Scott and Crossman 1973; Brumo 2006). In interior Oregon, overwinter holding areas are relatively close to spawning locations (Figure 3; Robinson and Bayer 2005). In southern California, upstream migration and spawning occurs earlier than in Oregon and British Columbia (Chase 2001).

In sea lampreys, the initial migration occurs during the late winter in both the Great Lakes and Atlantic Ocean, and pre-spawning holding occurs near river mouths or in estuaries (Applegate 1950; Figure 3). Anadromous sea lampreys cease feeding around January and remain near shore. During mid to late May, migrants enter coastal rivers and travel to the spawning grounds about 1.5–2 months prior to spawning during late June–early July (Scott and Crossman 1973; Beamish and Potter 1975). However reproduction has been reported to occur as early as March in Virginia and Maryland and as late as September in New Brunswick (F. W. H. Beamish 1980a). In the Great Lakes sea lamprey, migration begins during April and the fish generally spawn during June and July (Applegate 1950; Manion and Hanson 1980).

Upstream migration and spawning of anadromous sea and Pacific lampreys therefore appears to occur earlier at lower latitudes, and this is likely also true of the Great Lakes sea lamprey. Photoperiod appears to play a role in stimulating the hypothalamic-pituitary-gonadal axis during maturation and spawning (Sower 2003). The timing of the spawning migration of anadromous sea lampreys has been concluded to be a function of distance to the spawning grounds, water temperature, and latitude (F. W. H. Beamish 1980a).

Swimming abilities of upstream migrants

Body size in lampreys is generally correlated with available prey resources and the distance of upstream migration (Hardisty and Potter 1971; R. J. Beamish 1980). Differences in the kinds of natural barriers encountered also appear to have shaped the body size, swimming performance, and behavior of these parasitic lampreys (Table 3), and large body size may also be important for Pacific lampreys, given the prolonged duration of their pre-spawning holding period. Anadromous sea and Pacific lampreys migrate longer distances and are larger than Great Lakes sea lampreys (Scott and Crossman 1973; F. W. H. Beamish 1980a; Kostow 2002; Table 3). Anadromous sea and Pacific lampreys also encounter large variations in salinity and current velocity and direction (i.e., reversing currents in tidal areas) during their upstream migration. Correlations between body size and migratory distance have also been suggested within the Pacific lamprey. For example, large body size has been reported in larger, more interior rivers like the Columbia River, whereas relatively small Pacific lampreys have been observed in coastal streams (Kan 1975; Kostow 2002), although it is not known if these differences are due to inherited characteristics which could signify some type of stock structure (Keefer et al. 2009a; see "Orientation and homing," above).

Swimming performance in lampreys is largely a function of body size. Results from laboratory experiments with Great Lakes sea lampreys predicted that at 15°C and current velocities of 0.85 m/s, 400 mm long fish would be able to swim for only ~50 s, whereas those that were 500 mm long could swim three times longer (McAuley 1996). Similarly, the large anadromous sea lamprey, with a mean body length of 900 mm, had absolute swimming speeds faster than anadromous Pacific lampreys, with mean body length of 658 mm (Mesa et al. 2003; Almeida et al. 2007). However, when standardized for body size, temperature (15°C) and tag size (< 1% of the body mass of the fish), the critical swimming speeds for these two anadromous lampreys were similar (Pacific lamprey 1.1 BL/s, Mesa et al. 2003; sea lamprey 1.2 BL/s, Almeida et al. 2007). In both laboratory and field evaluations, Great Lakes sea lampreys and Pacific lampreys swam against velocities well above their critical swimming speed (> 2.7 m/s) by a saltatory "burst and attach" mode of swimming (McAuley 1996; Moser et al. 2002; Keefer et al. 2010). Anadromous sea lampreys also use this mode of swimming to negotiate difficult passage areas (Quintella et al. 2004).

The large body size, swimming speed, and swimming and climbing modes (see previous and below) of anadromous sea and Pacific lampreys may enable them to negotiate some large obstacles to reach upriver spawning sites. Obstacles to upstream migration of Pacific lampreys occur at natural waterfalls, low and high elevation dams, irrigation diversions (4), and probably also culverts. The characteristics common to these obstacles are a combination of rapid current velocity and the lack of sufficient attachment surfaces where the fish can hold and rest (Moser and Mesa 2009; Keefer et al. 2010). Obstacles to upstream migrating anadromous sea lampreys include moderate rapids and hydroelectric dams, whereas Great Lakes sea lampreys enter lower gradient streams with no natural obstacles (Table 3).

An important difference in the behavior of anadromous sea and Pacific lampreys when negotiating barriers is in their ability to "climb" vertically on a wetted surface. Pacific lampreys can climb vertical surfaces by attaching with their oral disc, contracting the body, and then releasing and reattaching a few centimeters higher

(Reinhardt et al. 2008); they are thus able to ascend continuous, perfectly-vertical, wetted surfaces > 1.7 m (Kemp et al. 2009). In fact, Pacific lampreys are capable of ascending the 12 m high Willamette Falls in the Willamette River, Oregon (4A and 4B); in the pre-dammed Columbia River, they would have encountered a raging 15 km series of rapids at historic Celilo Falls. In contrast, observations suggest that anadromous sea lampreys can ascend nearly-vertical barriers at heights of only 1.5–1.8 m (Scott and Crossman 1973), and Great Lakes sea lampreys are poorer climbers yet, being unable to ascend vertical heights greater than half of their body length (Reinhardt et al. 2009). To aid passage of Pacific lampreys at places where upstream passage is poor (e.g., dams), structures have been developed to take advantage of the climbing ability of Pacific lampreys by using steep ramps (≤ 60° angle) over which only a few centimeters of water flows (Moser and Mesa 2009).

Little is known about how hydraulic flow influences the behavior of migrating lampreys. Increases in stream discharge that occurs after rain or during the operation of hydroelectric dams can stimulate upstream migration in Great Lakes sea lampreys and anadromous sea and Pacific lampreys (Almeida et al. 2002; Keefer et al. 2009b; Binder et al. 2010).

Local flow characteristics may also influence lamprey behavior. For example, anadromous sea lampreys attracted to an Ice Harbor style of fishway at a dam were subsequently impeded from passing the dam due to adverse hydraulic conditions (Haro and Kynard 1997). Studies aimed at understanding how lampreys behave under various hydraulic conditions have the potential to predict migration routes, and would be beneficial for trapping and removal of Great Lakes sea lampreys, and for passing anadromous lampreys (Moser and Mesa 2009; Keefer et al. 2010).

Environmental cues to upstream migration

Lampreys are photophobic during their upstream migration and they migrate almost exclusively at night (Hardisty and Potter 1971). The Great Lakes sea lamprey (Kelso and Gardner 2000) and anadromous Pacific lamprey (Moser et al. 2002) (and presumably the anadromous sea lamprey), are most active within the first few hours following sunset. Lampreys avoid light during the day by hiding in deep pools, among large rocks, or within fallen brush and undercut banks (Kelso and Gardner 2000; Robinson and Bayer 2005; Binder and McDonald 2007). Despite this photophobicity, however, there is some indication that lampreys may be attracted to light at night; traps were five times more attractive for Great Lakes sea lampreys when the entrances were lit with a flashlight (Purvis et al. 1985). More research is needed on the efficacy of light attraction for control of the Great Lakes sea lamprey, and for conservation of anadromous sea and Pacific lampreys.

Temperature modulates upstream migration behavior, general health, and sexual maturation in lampreys (Binder and McDonald 2008; Clemens et al. 2009; Keefer et al. 2009b). The springtime spawning migration of the Great Lakes sea lamprey begins after stream temperatures exceed 10°C (Applegate 1950); sudden increases in temperature tend to stimulate migratory activity, while sudden decreases halt migratory activity in this fish (Applegate 1950; Binder and McDonald 2008; Binder et al. 2010). The response to temperature appears similar in anadromous sea lampreys (F. W. H. Beamish 1980a). Similarly, Pacific lampreys are first detected in the Columbia River at River Kilometer 235 (non-tidal fresh water) in May, when water temperature typically exceeds 11°C (Keefer et al. 2009b).

Rates of movement for Pacific lampreys increase during the summer as river discharge decreases and water temperatures rise (Moser et al. 2005; Keefer et al. 2009b), but slows in the fall when water temperature drops below 20°C (Robinson and Bayer 2005). Temperatures historically encountered during the entire migration for Great Lakes sea and coastal runs of anadromous Pacific lampreys are comparable: ~5–20°C (Applegate 1950; Kan 1975); whereas temperatures for anadromous sea lampreys are of a narrower temperature range: 15–21°C. Recently, however, temperatures > 20°C have been encountered by Pacific lampreys for prolonged periods of time in coastal and interior streams in the Pacific Northwest (Clemens et al. 2009). Similar prolonged warm water trends are also likely occurring within the geographical range of Great Lakes and anadromous sea lampreys, but Pacific lampreys are generally exposed to these river temperatures for much longer, owing to their prolonged freshwater residency (≥ 1 year versus a few months for sea lampreys). These warmer temperatures have been associated with significant, proportional decreases in body size and sexual maturation in Pacific lamprey during the following spring (Clemens et al. 2009). Effects of warmer temperatures on the maturation timing characteristics of Great Lakes and anadromous sea lampreys have not been investigated.

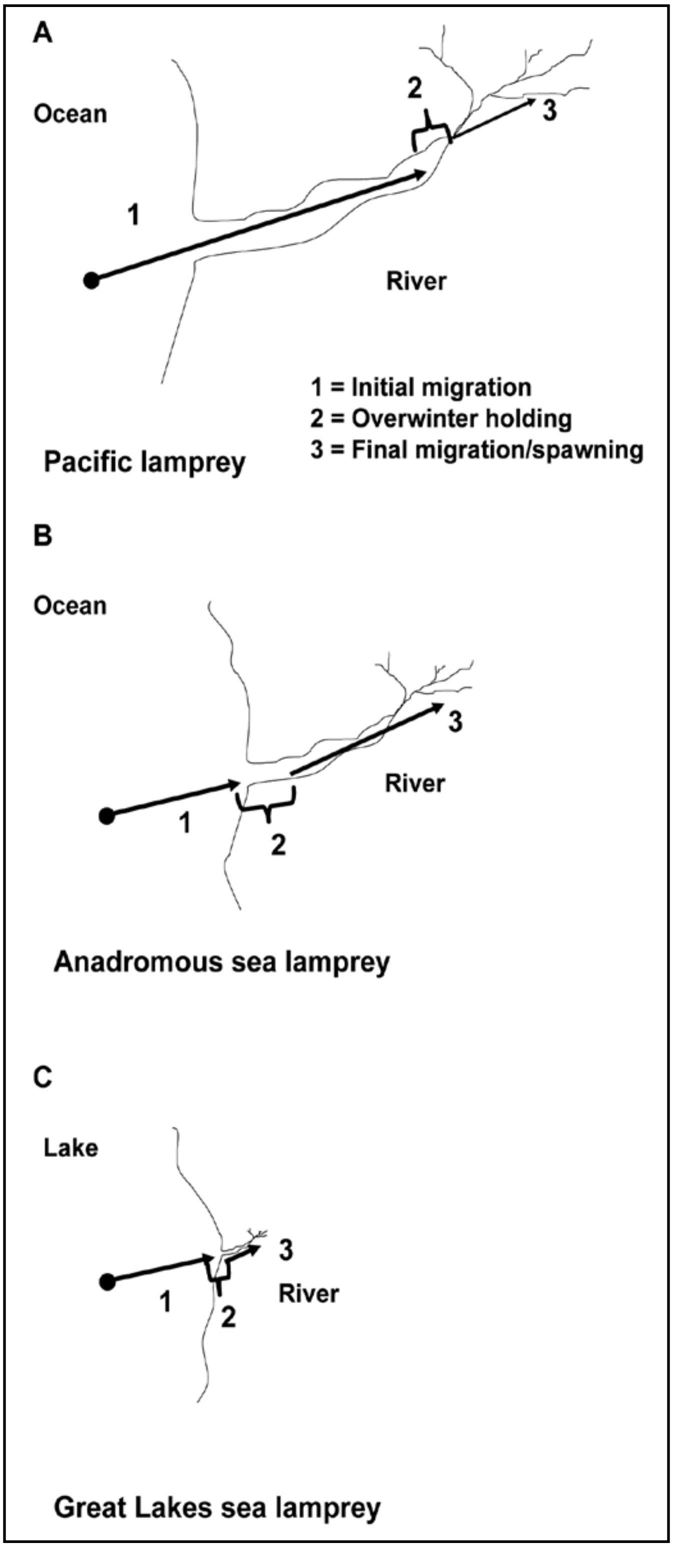
Sexual maturation, final migration, spawning, and death

All lampreys shrink considerably during their upstream migration. Anadromous sea lampreys decrease in body length by an estimated 19–24% between the initial migration and post-spawning (F. W. H. Beamish 1980a). Similarly, Pacific lampreys decrease in body length by an estimated 18–30% (R. J. Beamish 1980; Chase 2001). Great Lakes sea lampreys have the smallest decreases in body length, decreasing by an estimated 8–10% (O'Connor 2001). This smaller reduction in body length by the Great Lakes sea lamprey relative to the anadromous lampreys is likely related to the shorter migration distance (Figure 3). Reductions in body size are accompanied by a reduction in flesh quality and deterioration of organs to fuel sexual maturation (e.g., Larsen 1980; Clemens et al. 2009).

Lampreys are season- and temperature-responsive in the timing of their sexual maturation and reproduction (Sower 2003). Temperature regulation of migration and spawning behavior probably evolved in response to the strict thermal requirements of developing embryos (Piavis 1971). The thermal range for embryonic development of Great Lakes sea lampreys is between 15 and 25°C, with survival decreasing sharply as river temperatures deviated from the ~18°C optimum (Piavis 1971). The range is similar in anadromous sea lampreys (15–23°C; Rodríguez-Muñoz et al. 2001), but survival across this temperature range is more consistent than in Great Lakes sea lampreys. The thermal range for embryonic development of Pacific lampreys is broader than for sea lampreys (< 10–22°C; Meeuwig et al. 2005)1. This information on thermal ranges or embryonic development is from laboratories.

The spawning temperature for all three parasitic lampreys overlaps, although sea lampreys may have a higher peak spawning temperature than Pacific lampreys. Spawning of Great Lakes sea lampreys peaks at ~14–18°C (Scott and Crossman 1973; Manion and Hanson 1980), but has been observed at temperatures up to

Figure 3. Schematic comparison of the migration stages of the anadromous Pacific lamprey (A), anadromous sea lamprey (B), and Great Lakes sea lamprey (C) between the ocean or lake and river tributaries. The phases of the migration of the anadromous sea lamprey are thought to be similar to the Great Lakes sea lamprey. When the anadromous lamprey cease feeding about January, they are thought to be near shore. In May, anadromous sea lamprey begin to migrate into estuaries and then into freshwater streams. The relative migration distances amongst these lampreys are presented to scale. Note that the pre-holding migration and overwinter holding of the Pacific lamprey occur further up into the river system.



26°C (Manion and Hanson 1980). Anadromous sea lampreys in New Brunswick exhibit peak spawning at temperatures of 17–19°C (Beamish and Potter 1975) and in New Hampshire at ~18–21°C (Sower 2003). Spawning in Pacific lampreys has beenobserved at ~10–17°C, peaking at 13–16°C (Brumo 2006; Stone 2006). The apparent difference in peak spawning temperatures between sea and Pacific lampreys, however, may be due to fewer observations of Pacific lamprey spawning. The spawning season for Pacific lampreys ranges from March to July (Brumo 2006), similar to that reported for sea lampreys (F. W. H. Beamish 1980a), but—given its dependence on temperature—the spawning season varies considerably with latitude in both species (see "Overview and timing of upstream migration," above).

Spawning behavior seems to be similar in sea and Pacific lampreys. Males generally arrive at the spawning grounds first where they construct nests in substrate composed of rubble, gravel, and sand on the upstream edge of riffles, in areas of "moderate" unidirectional flow (Applegate 1950; Scott and Crossman 1973; Manion and Hanson 1980). In sea lampreys, females also construct nests towards the end of the spawning season (Scott and Crossman 1973; Manion and Hanson 1980). During the spawning period, the lampreys are nearly blind, and the lampreys will spawn during daylight hours (Applegate 1950). Female sea and Pacific lampreys orient across the nest while the male initiates a "gliding-feeling" motion prior to attaching to the female's head, wrapping around her, and squeezing the eggs out while fertilizing them (Scott and Crossman 1973). Genetic studies in the Great Lakes sea lamprey demonstrated that both sexes mate with more than one individual and matings with three or more individuals are common (see Docker 2006). These polygamous tendencies may be related to sex ratio (Scott and Crossman 1973; Manion and Hanson 1980), particularly as the result of sea lamprey control. Great Lakes sea lamprey populations have become highly female-biased following the initiation of sea lamprey control (Heinrich et al. 1980), and sex ratios may also vary during the season (Scott and Crossman 1973; Manion and Hanson 1980). However, much remains unknown about the mating systems of sea and Pacific lampreys under different conditions.

The total number of eggs is directly related to adult body size in lampreys. Accordingly, the large anadromous sea lamprey has the highest total fecundity, with an estimated mean fecundity of 171,589 to 210,228 eggs (reviewed in F. W. H. Beamish 1980a). The mean fecundity for the intermediate-sized Pacific lamprey ranges from 34,000 to 140,312 eggs (Scott and Crossman 1973; Kan 1975), whereas that of the relatively small Great Lakes sea lamprey ranges from 34,000 to 110,300 eggs (Scott and Crossman 1973). Further comparisons, such as the fecundity at spawning relative to the distance of the upstream migration ,would be informative.

Gonadal development, reproduction and hormones

Reproductive physiology and endocrinology has been useful in informing control practices of the Great Lakes sea lamprey (e.g., the release of sterile males; see Sower 2003), and it may be useful for breeding and culturing of Pacific lampreys for seeding barren streams.

The maturation process begins during the parasitic feeding phase of lampreys, before they enter fresh water for their spawning migration. Although currently unknown, these maturation processes may occur more slowly during the prolonged spawning

Table 3. Comparisons of migratory distance, duration, and maximum total body length. Details are provided in the text.

Parameter	Great Lakes sea lamprey	Anadromous sea lamprey	Anadromous Pacific lamprey
Relative migration duration	Few months	Few months	≥ 1 yr
Maximum total body length	rarely > 700 mm	≤ 800–900 mm	rarely > 800 mm
Relative migratory distance	≤ 79 km	320–480 km	≤ 700 km
Swimming ability	Poor[a]	Comparable to anadromous Pacific lamprey[b]	Comparable to anadromous sea lamprey[b]
Obstacles	Low-head barrier dams	Rapids, hydroelectric dams	Waterfalls, hydroelectric dams
Climbing ability	Poor	Modest[c]	Exceptional

[a] Direct comparisons of the swimming ability of Great Lakes sea lamprey are difficult to make with other lampreys because critical swimming speed has not been tested.

[b] Details provided in the text.

[c] Based on anecdotal observations noted in Scott and Crossman (1973). The climbing performance of anadromous sea lamprey has not been directly tested, as with Great Lakes sea lamprey and anadromous Pacific lamprey. (Reinhardt et al2008 and 2009; Kempetal 2009).

migration of Pacific lampreys. In males, spermatogonia proliferate and develop into primary and secondary spermatocytes, and in females, vitellogenesis occurs (Sower 2003). The final maturation processes, resulting in mature eggs and sperm, occur during the non-feeding, upstream migration. Gonad development, reproduction, and reproductive hormones have been studied extensively in the anadromous and Great Lakes sea lampreys, and there appears to be little or no difference between them (Sower 2003; Bryan et al. 2008). Except for a recent study (Mesa et al. 2010), little is known of the reproductive physiology of Pacific lampreys; this leads us to invoke the null hypothesis that there is no difference between sea and Pacific lampreys in their reproductive physiology and endocrinology. Evidence for a few exceptions to this hypothesis, however are noted below.

Higher brain centers integrate environmental and sensory stimuli and relay this information to the hypothalamus of the brain. The hypothalamus controls reproduction through the release of gonadotropin-releasing hormone (GnRH). Changes in levels of GnRH in the brain are correlated with season (photoperiod and temperature; Sower 2003). There appear to be three isoforms of GnRH (GnRH-I, -II, and –III) that control sexual maturation and reproduction in lampreys (Sower 2003; Kavanaugh et al. 2008); GnRH-II was identified only recently (Kavanaugh et al. 2008). The GnRHs act on specific receptors located in the pituitary gland. In sea lampreys, one known gonadotropin is secreted from the pituitary in response to hypothalamic GnRHs, and this pituitary hormone is thought to act on one glycoprotein receptor in the gonad and one in the thyroid (Freamat et al. 2008; Sower et al. 2009) to influence steroidogenesis and gametogenesis. Various studies on the structure and function of the GnRHs in sea lampreys have established that this fish has a hypothalamic-pituitary-gonadal axis similar to all other vertebrates with a high conservation of the mechanisms of GnRH action (Sower 2003; Kavanaugh et al. 2008; Sower et al. 2009). The primary amino acid and cDNA sequences of the three isoforms of GnRH, the cDNA of one GnRH receptor, one pituitary gonadotropin-β-like protein, and several other brain and pituitary hormones/receptors have been identified for the sea lamprey (see Kavanaugh et al. 2008; Sower et al. 2009). The cDNA of lamprey GnRH-III has also been cloned for Pacific lamprey (Silver et al. 2004).

Seasonal and sex-specific changes of the three GnRHs during the final reproductive period suggest specific roles for each of the GnRHs in male and female lampreys. Several lines of evidence suggest that GnRH-III is the major form regulating final maturation in lampreys, whereas GnRH-I may influence spawning behaviour (see Sower 2003; Docker 2006). Levels of GnRH-I remain relatively low in female sea lampreys during their final maturation while GnRH-III is present in higher concentrations and undergoes significant increases during this period (Sower 2003). A possible function for GnRH-II is not yet known, although a recent study showed that its levels were elevated in male anadromous sea lampreys early in the season, dropped and then peaked in mid-season, and finally declined prior to spawning (Sower et al., submitted). In females, GnRH-II concentrations were elevated at the beginning of the season and then dropped and remained low during the rest of the season. More research is needed to fully understand the function of the three GnRHs in lampreys, and to determine if there are differences among lamprey species. Blood plasma concentrations of 15α-hydroxylated steroids (see below) increased in both sea and Pacific lampreys when GnRH was administered (Bryan et al. 2003; Young et al. 2004). These studies suggest that GnRH-III was more potent than GnRH-I in Pacific lampreys (Young et al. 2004), but only in some instances for sea lampreys (Young et al. 2004, but see Bryan et al. 2003). However, differences in study design and stage of maturation of the lampreys make these comparisons between sea and Pacific lampreys difficult, and more research is needed to clarify differences and similarities between sea and Pacific lampreys.

The gonadotropin secreted from the pituitary acts on the gonad, which produces sex steroids. The physiological role of these steroids has mostly been studied in the sea lamprey (reviewed in Bryan et al. 2008). In earlier studies, classical plasma steroid hormones such as estradiol were measured as indicators of gonad maturation and reproduction in both sexes of the sea lamprey (Table 2) and other lampreys (Bryan et al. 2008), and the role of estradiol in reproduction is further supported by the recent cloning of an estrogen-like receptor in sea lamprey (Thornton 2001). Estradiol, but not testosterone, appears to be a major steroid regulating reproductive maturation and function in both sexes of the sea lamprey (Sower 2003; Bryan et al. 2008) and Pacific lamprey (Mesa et al. 2010). However, many questions remain as to the type of steroids

Figure 4. Willamette Falls, Oregon (A and B); lowhead barrier dam in a tributary to the Great Lakes (C); irrigation diversion dam in a tributary to the Columbia River (D). (Photos: Benjamin Clemens, Stan van de Wetering, Thomas Binder, and Mary Moser.)

that are synthesized and their respective functions (Bryan et al. 2008). For example, there is growing evidence that all lampreys produce gonadal steroids that are different from those of other vertebrates, by possessing an additional hydroxyl group at the C15 position (Bryan et al. 2006, 2008). Furthermore, there is evidence that 15α-hydroxyprogesterone is a hormone in lampreys, and that androstenedione, a precursor to vertebrate androgens, is the main androgen (Bryan et al. 2008), but more research is required.

Mating pheromone

Spermiating male sea and Pacific lampreys attract ovulating females to nest sites with a mating pheromone that is released through the gills. The primary component of this pheromone is 3-keto-petromyzonol sulfate (3kPZS; Li et al. 2003; Robinson et al. 2009). This compound is attractive to ovulating females at concentrations as low as 10^{14} mol/L (Johnson et al. 2009). However, as studied in Great Lakes sea lampreys, 3kPZS alone does not retain ovulating females near the source, suggesting that other components of the mating pheromone evoke near-source search behavior (Siefkes et al. 2005; Johnson et al. 2009). Electrophysiological studies have demonstrated that Pacific lampreys are also sensitive to 3kPZS, albeit at much higher concentrations than detected by sea lampreys (Robinson et al. 2009). A second component of the mating pheromone has been identified in sea lampreys (Li et al. 2003), but it is only detected by females at much higher concentrations than 3kPZS (Siefkes and Li 2004) and its function has not yet been tested.

The mating pheromone has recently been used to attract and trap females of the Great Lakes sea lamprey for removal (Johnson et al. 2009). The mating pheromone could potentially be used to attract Pacific lampreys with the goal of aiding upstream passage at dams and drawing the fish into barren streams.

SUMMARY AND CONCLUSIONS

We have reviewed the biology of the well-studied Great Lakes sea lamprey, an invasive pest, and compared this information with that of the anadromous sea and Pacific lampreys, which are of conservation concern. The key similarities, differences, and unknowns in the biology of these three parasitic lampreys are summarized in Table 4. The comparisons are necessarily generalized, and there are potentially myriad factors that might explain the biological differences, including phylogeny (e.g., at the level of genera or species),

Table 4. Similarities, differences and unknowns in the juvenile and adult phases among anadromous sea lamprey (ASL), Great Lakes sea lamprey (GSL), and anadromous Pacific lamprey (APL). Relevant citgations are provided in the text.

	Similarities	Differences	Unknowns
Juvenile—parasitic phase	ASL, APL parasitize fish en route to ocean ASL, GSL, and APL attach to similar locations on prey ASL and APL parasitize similar taxa in the ocean	APL cannot remain in fresh water; GSL can Body size of ASL > APL > GSL	Can all ASL stocks remain in fresh water? Confirm that migration timing depends on latitude in GSL Bioenergetics and host impacts of ASL, APL, growth rate data for APL
Adult—non-feeding phase: Initial upstream migration	Migration timing depends on latitude for ASL and APL Photophobicity and cryptic behavior Tendency to become quiescent in water temperatures < 10°C; and to actively migrate upstream when temperatures > 20°C	Body size of ASL > APL > GSL ASL are able to ascend rapids; GSL cannot ascend wetted, vertical surfaces; APL are able to climb waterfalls Different swimming capacities, likely a function of differences in body size	Confirmation that no APL can remain in fresh water Evidence for lack of homing to natal streams in ASL or GSL; inconclusive for APL Effectiveness of light to capture APL
Adult—non-feeding phase: Pre-spawning holding		*See differences in Figure 1 (Migration distance APL > ASL > GSL) APL can hold in fresh water for ≥1 year before spawning	
Adult–non-feeding phase: Final migration/spawning	Spawning characteristics and most secondary sexual characteristics	Male ASL and GSL exhibit prominent rope-like ridge anterior to first dorsal fin as they approach the spawning grounds, APL do not	Effect of sex ratio of mating systems in all Whether ASL and GSL enter river systems more sexually mature than APL Physiological characterization of maturation and bioenergetic status of APL

differences in environments (including selection pressures), and localized adaptations. Likewise, we do not know whether the similarities that we have found are due to evolutionary constraints on phylogeny and/or homoplasy.

In general, the large anadromous sea and Pacific lampreys, with their relatively long migratory distances, appear to have greater swimming abilities than the smaller Great Lakes sea lamprey. Anadromous sea and Pacific lampreys must negotiate hydroelectric dams and various man-made obstacles to access spawning grounds. The climbing abilities of anadromous sea lampreys are thought to be more modest, and climbing abilities of the Great Lakes sea lamprey are relatively poor. Pacific lampreys are adapted to the larger and more geologically-diverse rivers of the west coast of North America. Pacific lampreys exhibit a prolonged residence in fresh water prior to spawning and show exceptional climbing abilities. There are no natural obstacles to upstream migration for Great Lakes sea lampreys, and relatively low man-made obstacles have been used effectively to limit sea lamprey colonization of tributaries. In contrast to the Great Lakes sea lamprey, research on the Pacific lamprey has focused on improving passage success at dams and other man-made structures.

All three lampreys discussed in this paper have similar maturation and reproduction timing that is modulated by water temperature and seasonal photoperiod, although again Pacific lampreys reside in fresh water for a much longer period of time prior to spawning than sea lampreys. Mean total fecundity is directly correlated with body size, with the large anadromous sea lampreys having the most eggs, and the small Great Lakes sea lampreys the fewest. Knowledge of the reproductive physiology of sea lampreys has helped in the development of a sterile male release program in the Great Lakes Basin. In comparison, knowledge of the reproductive physiology of Pacific lampreys is poorly known but could inform conservation scenarios aimed at culturing these fish for reintroduction into barren streams. The migratory and mating pheromones are relatively well known for sea lampreys, but have been studied comparatively little in the Pacific lamprey. Control of the Great Lakes sea lamprey has recently employed use of pheromones to attract and trap lampreys, whereas restoration of the Pacific lamprey might benefit from future use of pheromones for facilitating upstream passage over dams and into barren streams.

The extensive information base on the Great Lakes sea lamprey is a result of a management agency (the Great Lakes Fishery Commission) with a clear directive aimed at controlling this pest. By comparison, the relatively scant information available for anadromous sea and Pacific lampreys is a result of the lack of a similar organized effort to fund and coordinate research that can inform conservation of these imperiled fishes. Given these different goals for these North American parasitic lampreys, we wonder what basic or applied biological parameters have been ignored and will deserve more attention. Awareness of this bias in both the volume of the scientific literature and the goals behind this literature may aid intelligent, creative, and novel approaches to the management and conservation of sea and Pacific lampreys in North America. Some key similarities in biology do exist between anadromous sea and Pacific lampreys (Table 4), but these similarities should be used with caution. Likewise, differences between the invasive Great Lakes sea lamprey and the anadromous lampreys (Tables 1 and 4) cause us to question the appropriateness of using the vast amount of information garnered from Great Lakes sea lampreys as a useful surrogate for native anadromous sea and Pacific lampreys. Assumptions of reciprocal biology should be stated as explicit hypotheses that need to be vigorously tested to verify whether lessons learned from one lamprey species may be beneficial in the management or control of another.

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FEATURE:
FISHERIES MANAGEMENT

Tagging by Lobster Fishermen to Estimate Abundance of the Discarded Portions of Their Catch

ABSTRACT: The cost of tagging studies can be greatly reduced if fishermen tag, release, and recapture during fishing operations. Some population components captured during fishing can not be legally retained. If these components are returned to the sea unharmed, their abundance can be estimated. Lobster tag, release, and recapture data were obtained by fishermen during their fishing activities over a 9-week season. Tags were inexpensive and easy to apply to cable ties. Abundance of ovigerous females and window females (non-ovigerous females, 114-124 mm carapace length) were estimated for seven and three fishing grounds respectively. When lobster fecundity was included in the calculations, annual egg production was also estimated. Fishery management applications include measuring the benefits of a regulation, and setting reference points to the numerical abundance of a life history stage. Experimental and area-specific management are more affordable if fishermen can collect data for stock assessment during their fishing operations. Data quality depends on carefully communicating the purpose and procedures to fishermen, and on designing a data sheet to reduce recording errors.

Marcado de langosta por parte de pescadores para estimar la abundancia de los descartes en la captura

RESUMEN: el costo de los estudios de marcado puede reducirse sustancialmente si los pescadores mismos marcan, liberan y recapturan a los animales durante las operaciones de pesca. Algunos componentes poblacionales que son capturados durante las faenas no pueden ser retenidos legalmente. Si estos componentes se regresan intactos al mar, entonces es posible estimar su abundancia. Los datos de marcado, liberación y recaptura de langosta fueron tomados por los pescadores durante las actividades de pesca a lo largo de una temporada de nueve semanas. Las marcas fueron poco costosas y fáciles de aplicar. Se estimó la abundancia de hembras ovígeras y no ovígeras (éstas últimas con longitudes de carapacho de 114 mm a 124 mm) para siete y tres zonas de pesca, respectivamente. Cuando la fecundidad de las langostas fue incluida en los cálculos, también se estimó la producción anual de huevos. Las aplicaciones para el manejo pesquero incluyeron la medición de los beneficios de una regulación y el establecimiento de puntos de referencia para la abundancia numérica de los estadios de vida. El manejo experimental y por áreas es más costeable si los pescadores, durante las operaciones de pesca, pueden colectar datos útiles para la evaluación de los stocks. La calidad de los datos depende de que a los pescadores se les comunique cuidadosamente el propósito y procedimiento que implica el estudio así como del diseño una hoja de captura que reduzca el error en los registros.

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Figure 1. The American lobster is tagged with a small cable tie on the rostrum and a larger one on the merus. (Photo: Robert Semple)

1. INTRODUCTION

In this study, fishermen did all of tag, release, and recapture of American lobsters (*Homarus americanus*) in a trap fishery. (Fishery biologists usually conduct the tag and release portions of tag-recapture studies and depend on fishermen for recaptures.) The guidelines for how to tag, release, and recapture are fairly uniform in America and Canada. Any population component that is captured by the fishery,

but required by regulation to be returned to the fishing ground, is a candidate for measuring its abundance.

Possible components are lobsters below the minimum legal size and above the maximum legal size, tail-notched females, ovigerous females, and window females (Miller, 1995). Depending on the size of lobster trap escape gaps, a portion of the lobsters under legal size is retained. One or both sexes larger than a prescribed size (usually 127 mm CL) are protected in parts of the U.S. and Canada. Ovigerous females are protected everywhere in the U.S. and Canada. Females which are tail-notched when ovigerous, retain the notch during the non-ovigerous period and are protected in parts of the U.S. and Canada. Window females are large, mature females within a size interval (e.g. 114-124 mm CL), which are vulnerable to fishing because they are non-ovigerous. However, if protected, they will become ovigerous the following summer, and escape fishing mortality until they molt to a larger size. They are protected in parts of Canada. Protecting egg production is a primary objective of fishery regulations in both the spiny (Phillips et al. 1994) and clawed lobster fisheries (Bennett 1980; Miller 1990).

This paper describes the mark-recapture methods, estimates egg production, estimates the number of window and ovigerous females, and reviews reasons for success and failure. The method could be used in trap fisheries for other species (e.g., spiny lobsters, crabs, prawns, sablefish) in which the catch illegal to retain is returned to the water unharmed.

2. METHODS

2.1. Tagging

In initial trials, fishermen were instructed to record daily how many ovigerous or window females they tagged, how many tagged were captured, and how many untagged were captured. The number of untagged captured and newly tagged released were similar, but not all untagged lobsters were tagged. Also, some fishermen only recorded releases and not recaptures. In later trials, fishermen were asked to tag but not record recaptures until after the first 5-weeks of the season when adequate numbers of tagged lobsters had accumulated on the grounds. In the last 4-weeks they were asked to record recaptures and releases.

Lobsters were tagged with cable ties around the rostrum and/or around the long leg segment (merus) proximal to the claw (Fig. 1). They were secured tightly between spines so the tags did not interfere with moving parts of the lobster, and any excess cable tie was snipped off. It was easier to constrain lobsters for tagging the rostrum than the merus. Most tags were not numbered, and when they were, the numbers were ignored. Cable ties are available in a variety of colors and sizes at most hardware and auto supply stores, and cost only a few cents each. Lobsters discard tags with the shell when they molt.

2.2. Population size and egg production

Abundance of ovigerous females was calculated for each of the final 4-weeks of the season using the Peterson method (adapted from Ricker 1975). PO_i is population size in week i; ti is the number of untagged, and ri the number of tagged lobsters captured in week i; and T is the cumulative number of tags released on a fishing ground from the beginning of the season to the midpoint of week i. When a fisherman recorded releases but not recaptures,

$$PO_i = \frac{(t_i+r_i+1)\ T}{r_i+1} \qquad (1)$$

these were included in T only. These three inputs were summed up over a week for all participants on a fishing ground.

Untagged lobsters would only be captured once in a week because most were tagged at first capture; however, tagged lobsters could be captured more than once. This would result in an overestimate of recaptures and underestimate of population size. However, two data sets suggest the bias was less than 5%. Weekly captures of all tags at large were usually in the range of 2-9% (Tables 1 and 2). A different tagging program on large females was in progress in the same area at the same time (2003) using numbered tags. There, over the entire 9-week season, 1,489 lobsters were captured an average of 1.26 times (N. Baker-Stevens, Eastern Shore Fishermen's Protective Association, pers. comm.).

A single estimate of the annual egg production on a fishing ground (EO) was calculated from the mean of the four weekly estimates of ovigerous females (PO mean), the mean carapace length of ovigerous females (CL) on the fishing ground as

Table 1. Population sizes of ovigerous females and egg production for 2003.

Port	Week	Total tagged	Untagged	Recap.	Ovigerous population	Annual egg prod. x 10^6
Whitehead	6	747	103	16	5,276	
	7	884	98	19	5,216	
	8	1,026	119	31	4,841	
	9	1,246	221	40	7,969	
				mean	5,825	88
Port Felix-Cole Harbour	6	1,322	229	91	4,612	
	7	1,599	118	60	4,695	
	8	1,835	272	149	5,182	
	9	2,098	230	42	13,326	
				mean	6,954	125
Larrys River-Torbay	6	1,115	153	56	4,101	
	7	1,376	63	66	2,669	
	8	1,545	76	85	2,912	
	9	1,657	37	30	3,637	
				mean	3,330	67
New Harbour	6	779	99	38	2,727	
	7	878	49	16	3,413	
	8	999	45	10	5,090	
	9	a	a	a		
				mean	3,743	71
E. Halifax County	6	931	278	123	3,018	
	7	1,326	142	69	4,019	
	8	1,622	188	96	4,766	
	9	1,895	203	101	5,669	
				mean	4,368	84
Musquodoboit Harbour	6	323	181	52	1,426	
	7	486	86	41	1,481	
	8	606	126	53	2,020	
	9	743	210	77	2,747	
				mean	1,919	32
Petpeswick	6	349	145	40	1,588	
	7	446	48	27	1,213	
	8	501	62	24	1,743	
	9	583	103	43	1,954	
				mean	1,625	24

[a]insufficient data

obtained from at-sea samples on fishing boats, and the fecundity-carapace length relationship from Campbell and Robinson (1983). This represents annual egg production because females

$$E_O = (0.00256\ CL^{3.409})\ P_{O\ mean} \qquad (2)$$

produce no more than one clutch annually, and these hatch after the fishing season. Campbell and Robinson (1983) measured fecundity within 1-2 months of hatching and after most egg loss had occurred during the 12 month ovigerous stage.

Population sizes of window females (non-ovigerous 114-124 mm CL) in week i were calculated using the same method as for ovigerous females (equation 1). This was during June, 1-2 months before egg extrusion (Campbell, 1986; Ugarte, 1994). To calculate egg production from this group, the portion not extruding eggs, and the female mortality during the following ovigerous year before eggs hatch, needed to be accounted for. Fecundity of an average sized window lobster (119 mm CL) is 30,000 eggs (Campbell and Robinson, 1983). Waddy et al., (1995) state that most females of window size extrude eggs every second year. From window females tagged in 2002 and recovered in 2003, 155 of 159 were ovigerous. Others may have molted and lost their tag. We assumed 3% for each of molting and non-extrusion, giving a probability of extrusion of 0.94. Natural mortality estimates are sparse. Ennis (1979) estimates 2%, and Thomas (1973) 2-30%. We set the probability of annual survival at 0.90. Substituting in the following equation we obtain 1-year egg production from window lobsters where PW mean is the mean of four weekly estimates of the number of windows.

$$EW = 30{,}000(0.948)(0.9)PW_{mean}. \qquad (3)$$

Confidence limits are large. For example, in Table 1 for week 9 at White Head, the population estimate of 7,969 had a 95% confidence limit of 6,200-10,548. However, as discussed in section 3.1, bias may be a greater problem. Averaging four weekly estimates may improve both accuracy and precision.

3. RESULTS

3.1. Assumptions of mark-recapture studies (Ricker, 1975)

The marked fish suffer the same natural mortality as the unmarked and do not lose their marks. Lobsters are nearly always vigorous when removed from traps, and these were tagged and returned to the water within a few minutes. Also, 34 lobsters, equally divided between sizes of 0.5 kg and 1.3 kg, were each tagged with a cable tie around the rostrum and around the merus, and held communally in laboratory tanks for 12 months. None died and no tags were lost. Tagging studies reported here lasted only 9 weeks, the duration of the fishing season.

The marked fish are as vulnerable to fishing as the unmarked. In several ports the ratio of tagged to untagged ovigerous females didn't increase at the end of the season (Table 1) as one would expect from an increasing number of tagged lobsters in the population. An increasing catchability through the last weeks of the season would explain this result and would bias low the density estimates in early weeks. Dunnington et al. (2005) obtained higher density estimates from diver counts than from tag-recapture for legal (>83 mm CL) sizes, but not for sublegal sizes, and concluded some lobsters were not trappable. Their result could have been accentuated by an intense fishery that removed catchable legal lobsters from the study area. Weekly estimates for window females change less during the season (Table 2). Because the target populations are not depleted by the fishery, multiple estimates are possible over time.

The marked fish become randomly mixed with the unmarked. We hoped the distribution of fishing effort spanned the distribution of lobsters. However, some fishermen move their traps from deep to shallow water as the season progresses, with the intent of following a migration of lobsters inshore. If part of the population remains inshore and part offshore so that fishermen who move are sampling a new component, then results will be biased. Early season the population will be underestimated because some untagged lobsters are not vulnerable to capture, and late season the population will be overestimated because some tagged lobsters are invulnerable to capture. Cowan et al. (2007) found ovigerous females >93 mm CL (carapace length) wintered in deeper water than ovigerous <93 mm CL, and remained deeper through the summer hatching period. Ovigerous females spanned a large size range, ~80-130 mm CL. Lobster size shouldn't bias results for window females as they are all 114-124 mm CL and non-ovigerous. If the bias is consistent or not large, the relative measure of abundance is still useful.

All marks are recognized and reported on recovery. The tags were conspicuous. If a fisherman's ratio of recaptures to releases were significantly lower than others, his recovery data was not used. Suspected recording errors were usually confirmed by discussions with fishermen. All tag releases were used for a correct count of total tags in the population.

There is only a negligible amount of recruitment to the catchable population during the time the recoveries are being made. Recruitment by growth is not a problem because all releases and recaptures are within a 9-week spring fishery, before molting occurs in July-October (Ugarte, 1994). Tagging studies at several locations have shown little long-shore movement in eastern Nova Scotia. Among lobsters at large for more than 1-year, in one study only 3 of 698 were recaptured greater than 12 km from the release points (Miller et al. 1989), and in another study, 80% of 2096 recaptures were less than 6 km from the release points (Tremblay et al. 1998). Fishing areas of ports in Tables 1 and 2 included long-shore distances of 8-15 km.

In summary, if a portion of the target population chooses not to enter traps. the population is underestimated. If the popula-

Table 2. Population sizes of window female lobsters and window egg production in 2002-2003.

Port/year	Week	Total tagged	Untagged	Recap	Window population	Annual egg prod. x 10^6
Whitehead	6	330	72	49	805	
2002	7	409	66	60	852	
	8	467	44	39	981	
	9	498	18	18	969	
					mean 902	22
Dover	6	357	23	10	1106	
2002	7	414	17	13	917	
	8	471	32	14	1478	
	9	a	a	a		
					mean 1167	30
Canso	6	273	53	13	1306	
2002	7	343	37	17	1049	
	8	408	58	17	1722	
	9	461	23	10	1424	
					mean 1375	34
Canso	6	438	69	32	1353	
2003	7	552	80	34	1814	
	8	654	76	43	1786	
	9	743	63	53	1614	
					mean 1641	40

[a] insufficient recaptures

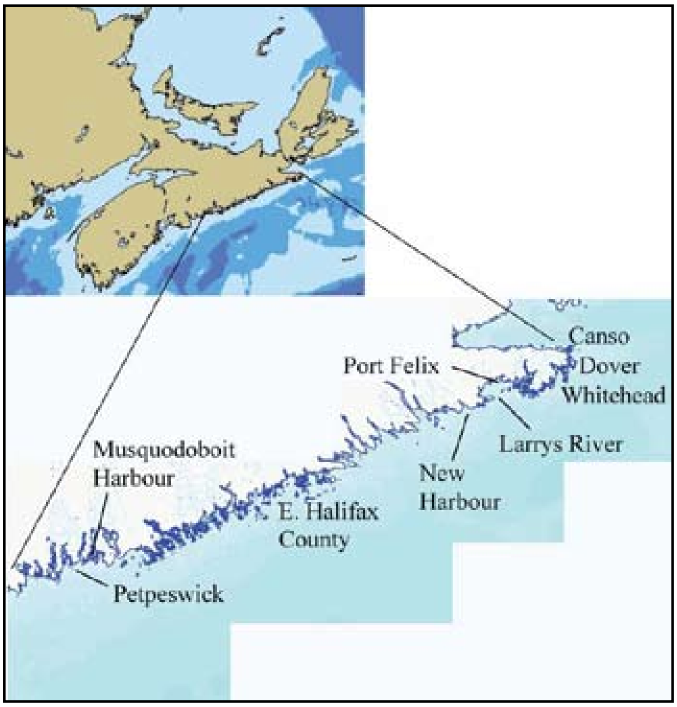

Figure 2. Nova Scotia locations where ovigerous females and window females were tagged.

tion is not mixed, as could be the case for ovigerous females, a low bias early in the season and a high bias later results. Averaging weekly estimates could reduce bias in the final estimate. Lobster mortality, loss of marks, immigration, and emigration were not issues of concern.

3.2. Window female tagging

The window population and resulting annual egg production are available for three fishing grounds (Fig. 2; Table. 2). The 2002 egg production from window lobsters was 22-34 million in these ports. If exploitation rate in this fishery is 50-60% (FRCC, 2007), then in the first year the conservation benefit from protecting window females is 50-60% of this egg production. Further benefit would accrue from the portion of the protected cohort that survived to spawn in subsequent years. The 19% increase from 2002 to 2003 in the Canso population is not unreasonable and could reflect either change in population size or measurement error.

3.3. Ovigerous female tagging

In seven ports, population size ranged from 1,625 to 6,954 lobsters, and annual egg production ranged from 24 to 125 million (Fig. 2; Table 1).

Problems in data quality were greater for ovigerous females than for window females. Ovigerous females were much more numerous, and the objective to tag all that were captured was ambitious. Some fishermen stopped tagging during the season, or not all tag recoveries were recorded. The most common error was failure to give dates of recapture. Recovery data were excluded when data problems were suspected. Ports with sufficient data on recoveries tagged 7,817 ovigerous females.

3.4. Cost

Most costs are the same for conventional tagging and tagging by fishermen, but the total is much higher for the former. The following example, in units of person days of work, is for 10 participating boats in one port. However, for conventional tagging, preparing data sheets (1-d), distributing data sheets, and explaining the program (1-d), visiting fishermen mid-season (2-d), recovering data sheets (1-d). Tagging by fishermen would require the same effort; tags would be delivered with the data sheets. For a biologist to accompany fishermen to tag either 1,000 ovigerous or 400 window lobsters by week 6 (early enough for tags to be recovered) would require about 80 person days. Estimating the mean size of ovigerous females for equation 2 would require 2 fishing days for the tagging by fishermen option, if a fishermen could not be found to provide these measurements. Thus, the conventional tagging requires 87 d and tagging by fishermen 9 d. Tagging lobsters that must by law be released also saves the cost of releasing saleable lobsters.

4. DISCUSSION

4.1. Improved data collection

All participants were volunteers without coercion; data sheets included explanations on their use with examples; fishermen representatives in each port were available by telephone to answer questions; and data sheets were given to fishermen individually, and their use briefly explained. In spite of this effort, about 60% of the tag recovery information was unusable for reasons given in 3.3.

A revised data sheet would reduce recording errors. Each day of the season would be pre-entered to reduce incorrect date entries. For the first few weeks only the number of new tags released would be recorded, because recoveries are too few to be useful for population calculations. Later in the season, columns would be added for the number of lobsters caught with and without tags. Tagging need not continue into the final week of the season, because these lobsters would have little opportunity to be recaptured.

4.2. Applications to management

Reference points and decision rules can be based on numerical abundance of any measureable population component. For example, egg production at White Head was 88 million in a year when catches were about double the long term average. One could use these results to set rules, e.g., to decrease exploitation if egg production dropped below 60 million and to allow increased exploitation if egg production exceeded 90 million.

Egg production from window females was 22 million for Whitehead, about one-quarter of the total. This result can be used to decide whether one-quarter is enough to justify the window conservation measure. With temporary changes in regulations, and additional tagging, this benefit could be compared to increasing minimum legal size or adding a maximum size. The apparent large range in larval survival among fishing grounds is an argument for area-specific reference points (Miller et al., 2006; Miller and Hannah, 2006).

These are examples of an empirical approach involving fishermen in data collection. We cannot satisfy well the data requirements of models such as eggs per recruit (Caddy, 2001; Miller and Hannah, 2006). We lack an empirical basis for choosing a reference point that will avoid a downturn in landings, or attain a target level of sustainable yield. Without an established relationship between reference points and fishery yield, we are left to manage by "probable good." High total egg production, or multiple spawner year classes in the population, will not hurt fishery yield and may help (Campbell, 1985; Miller, 2003).

If surveys of life history stages reflect true abundance, then we need not wait for fishery landings to tell us whether changes in regulations, fishing effort, or the environment are affecting the population. We have measurements of population response sooner, and in terms stakeholders can understand.

Advantages of the tagging method described are several. Any population component captured but not retained can be measured. Abundance is measured over a fishing ground rather than per unit area or in yield per recruit. Fishermen can tag, release, and record recaptures during normal fishing operations without dedicated personnel on board. Releases are widely distributed. Migration is less than in longer term studies, and there is no complication of lobster growth. A tagging project is completed within a fishing season. Multiple (weekly) estimates of abundance are possible because the target population is not depleted by fishing. Results are available the same year. The tag is inexpensive, robust, and easy to apply. One-on-one instruction of participants is required. Communication is the biggest cost.

ACKNOWLEDGMENTS

Helen Painter of CRAZY H Designs drew the cartoon.The Guysborough County Inshore Fishermen's Association, the Social Sciences and Humanities Research Council, and the Canada Department of Fisheries and Oceans contributed financially to this study. Guysborough County Fishermen and the Fishermen's Association interns participated in data collection.

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To the editor:

We read with interest the recent article by Woody et al. (Vol. 35, No. 7, pages 321-331, July 2010). It included a thoughtful review of the potential effects of hardrock mining on aquatic ecosystems, as well as useful policy change recommendations that we (along with the authors) hope will spark dialogue among all potential stakeholders. It also, however, included some information pertaining to a specific mine site, with which we are very familiar, that is out of date. With this in mind, we write to you today to provide current aquatic resource information for the mine site, and (perhaps more importantly) to share with the Fisheries readership a "good news" story as it relates to the potential for the positive impacts resulting from mine site rehabilitation on fish and fisheries resources.

Blackbird Creek Mine near Salmon, Idaho is used by the authors as a case study to "… exemplify frequent compatibility issues existing between fisheries resource conservation and hardrock mining." The article indicates that among other things Panther Creek, a Salmon River tributary downstream of the mine, once supported fish, but by 1960 the Steelhead and Snake River spring/summer Chinook Salmon were extirpated. Overall, based on the text of the article, the reader is left with the impression that widespread adverse effects on the aquatic ecosystem as the result of the Blackbird Creek Mine persist. In fact, nothing could be farther from the truth.

Since 2002, we have completed annual biomonitoring studies in the Creek watershed on behalf of the Blackbird Mine Site Group (BMSG), a consortium of several private mining interests that own the now closed mine. These studies have included the assessment of aquatic habitat conditions, as well as benthic macroinvertebrate and fish collections according to the bioassessment methodologies of the Idaho Department of Environmental Quality (DEQ) Beneficial Use Reconnaissance Program (BURP). The BURP is used to determine coldwater aquatic life use support (ALUS) in the state's running water environments. This program is part of the State's reporting requirements under the Clean Water Act.

Based on our work, the following conclusions regarding the current conditions in Panther Creek can be made:

- The benthic macroinvertebrate community is abundant and diverse, includes representative metal sensitive mayfly, stonefly and caddisfly taxa both upstream and downstream of the mine;
- Fish show no upstream-downstream differences in terms of density, biomass, condition or growth in response to drainage from the mine site;
- All life stages of resident and anadromous salmonids are supported, including natural reproduction by Chinook Salmon; and
- Stream reaches downstream of the mine score in the highest condition rating category within the ALUS framework, comparable to the "least impacted" streams and rivers in the state, providing a further indication of the level of recovery.

The recovery of the Panther Creek aquatic ecosystem is the direct result of remediation and rehabilitation activities implemented by the BMSG over the last number of years. While too numerous to list, these activities have resulted in significant improvements in water quality in Panther Creek. The improved water quality has paved the way for the biological recovery of the system, described above.

Again, we certainly had no intention by way of this letter to take away from the important message brought forward in the article by the authors. Any mining stakeholder must recognize that pro-active management of the environment is much more desirable than reactive management, and policy changes that continue to move us in that direction should be enacted. We did, however, feel strongly that the story of the recovery of Panther Creek is one that would be of interest to the readership.

Yours truly,

Ecometrix Incorporated
Brian Fraser and Robert J. Eakins

The author replies:

We thank Fraser and Eakins for their 7 September comments on Woody et al. (2010), and for the positive news concerning treatment of the Blackbird Creek Mine site, including the recent return of salmonids to Panther Creek (as indicated in their letter to the editor, and EcoMetrix 2010). Unfortunately, that report was unavailable to us at the time we submitted our article, and we are grateful to Troy Saffle (Idaho DEQ) for providing an electronic copy of it and Golder (2010). These reports make interesting reading for those interested in the past, present, and potential effects of hardrock mining on surface and ground waters. Despite the positive news concerning Panther Creek biota downstream of the mine site, EcoMetrix (2010) noted that Idaho water quality criteria and coldwater biota were not achievable in Blackbird Creek (which is the location of mines, tailings impoundments, and a water treatment plant). Because standards attainment was not predicted to occur in a reasonable time period, the State of Idaho drafted a use attainability analysis which removed Clean Water Act designated uses from Blackbird Creek, and facilitated site-wide remedial actions (Mebane 1997).

In addition, we presume that the Panther Creek biomonitoring sites selected on an ad hoc basis focused on habitats where both fish and benthic macroinvertebrates would be prevalent. It is unknown if sampling sites selected via a probability design would have yielded equally productive biomonitoring sites. Therefore, we caution EcoMetrix (2010) about inferring its site monitoring results to the entire stream without using such a design (Paulsen et al. 1998, Smith and Jones 2005).

Golder (2010) adds additional insights concerning the mine site. Golder reported that an HDPE (plastic) pipeline break occurred in June 2009, releasing over 30,000 L of untreated water into Blackbird Creek, but because of dilution, Panther Creek water still met Idaho DEQ chronic and acute criteria for copper. Even though water quality data prior to 2007 does not reflect the current state of the cleanup, and remedial actions were constructed to reduce copper levels, we observed that annual spring spikes in copper from Blackbird Creek exceeded Idaho copper criteria in 10 out of the 11 past years at the monitoring sites downstream in Panther Creek. These spikes were associated with increased springtime groundwater levels and high flows in Blackbird Creek. The spikes appear to have lasted only during the high flows, which lasted about 1-2 weeks. A potentially greater concern coupled with the spikes and criteria violations are the 1.6-3 m increases in well head levels in the tailings area, and at the tailings dam face over the past 8 years. If those waters reach critical elevations, they will have to be treated to avoid a second round of surface water contamination and possible dam rupture.

In conclusion, rehabilitation and mitigation projects that succeed are admirable, but it should be remembered that these projects are needed because of past negligence and insufficient regulatory standards that resulted in damage to intact and functioning ecosystems. Now that we are the wiser for past problems, it would be far better if these systems were protected and prevented from being broken rather than continuing to permit poorly thought-out projects that are likely to require perpetual mitigation, often by future generations of taxpayers. Our concerns with hard rock mining expressed in Woody et al. (2010) stand.

Robert M. Hughes

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COLUMN: DIRECTOR'S LINE

Gus Rassam
AFS Executive Director
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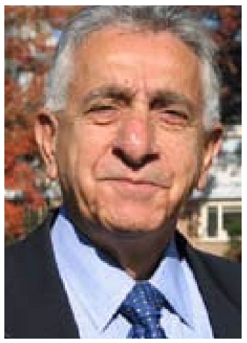
grassam@fisheries.org.



AFS journal publishing moves into a new era

Since 1872, AFS has been publishing the best and most complete scientific information on fisheries, fulfilling our primary mission to disseminate scientific information to scientists and professionals around the world. Following the publication of the first issue of *Transactions* in 1872, AFS has published a separate journal on fisheries management, another on aquaculture, and still another on aquatic animal health.

To meet the needs of the general membership we have been publishing a monthly magazine/journal, *Fisheries*, and, more recently, we began publishing an online open-access journal, *Marine and Coastal Fisheries.*

Over the years, the AFS journal program has provided a major share of the net revenues of the Society, thus allowing support for non-revenue-generating programs, such as: public information, policy development, and various scholarship and educational opportunities.

While volunteers (editors and reviewers) do the essential quality control in our journals through their dedication to peer review, our staff—working with an outside vendor—prepares the journals for final publication. Through 2010, this vendor/partner (with one exception) has been Allen Press. They take papers accepted for publication in the five regular journals, and produce both the print and the online version, do the distribution through the mail or the Internet, and generally provide access and other services to the user. The exception is *Fisheries* magazine, which shares the same vendor on the production/printing/distribution side, but is composed in-house at AFS through desk-top publishing.

Starting with the first issues of 2011, AFS will begin publishing all of its journals using a partnership with the well-renowned, major commercial publisher, Taylor and Francis.

Two main considerations went into the decision to change publishing partners: one is the relatively small size of AFS and its limited resources, severely restricting its ability to market its journals in a rapidly changing global market; second, the even more rapidly changing technology for online access to the user needed to be addressed. In both these areas, we feel that our new partner, Taylor and Francis, will be able to enhance our capabilities and visibility.

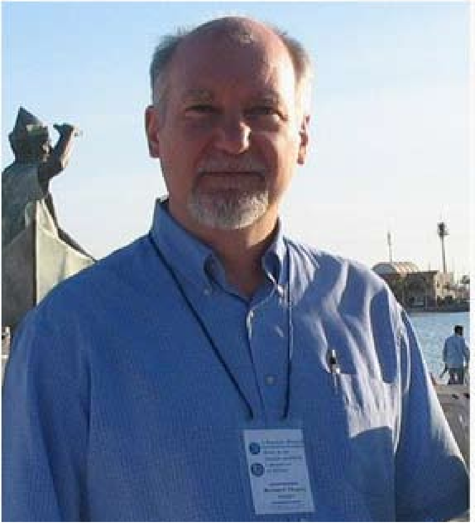
AFS is fully committed to keeping control on the editorial integrity and pricing of its journals,whether for individual subscribers or for the libraries and institutional subscribers. So what should our members and subscribers expect to see coming out of this new partnership?

- While the look and presentation of the journals may change starting with the first issue of 2011, the contents will continue to be fully vetted and scrutinized by the same editorial team and structure that AFS has always employed, thus assuring the continuous integrity and highest quality of our journals.
- AFS will maintain its policy of very modest price changes for its library subscriptions. Our individual member subscribers will see no change in the price of subscription for next year; and, in both cases, such pricing will be determined by AFS.
- We expect to see improvements in access to, and use of, our journals from individual scientists from all over the globe.
- We expect to see better access to our archived materials.
- There will be continuous enhancements to our legacy database, Fisheries InfoBase, by adding the non-science articles of the earliest issues of the *Transactions*.
- Every issue of *Fisheries* magazine will be in full-color.
- Our journals will be shown at various meetings in North America as well as internationally.
- The financial return to the Society will be maintained and improved.

Change is often difficult and can certainly be uncomfortable, yet change is inevitable as the dynamics of the external environment shift. With this new partnership, we know we're adapting to change and are heading in the right direction for AFS and for our journal authors and users.

OBITUARY:
BERNARD ANDREW MEGREY

Research Fishery Biologist



Bernard A. Megrey, 60, died in Seattle, Washington on October 1, 2010. He was born in Latrobe, Pennsylvania. He graduated from Cleveland State University, Ohio (B.A. 1974), Miami University in Ohio (M.S. 1978), and the University of Washington, Washington (Ph. D. 1989). Bern is survived by his wife Ronnette, sons Christopher, Nicholas and daughter Sarah.

Bern was employed as a Research Fishery Biologist with the National Marine Fisheries Service, Alaska Fisheries Science Center in Seattle Washington since 1982, and as a Project Leader since 2002. His career spanned a broad spectrum of activities within his chosen discipline, including fish population dynamics, stock assessment, fish reproductive biology, ecosystem simulation, and climate impacts on marine ecosystem production—all demonstrated by numerous significant accomplishments at a regional, national, and international level. Throughout his career, Bern received numerous awards, most recently in 2009 with the AFS Oscar Elton Sette Award for Outstanding Marine Fishery Biologist, and the PICES Ocean Monitoring Service Award.

Bern's accomplishments and contributions to science, marine fish biology, professional development, mentoring students, scientific collaboration, cooperation, and working to instill the best science possible at every opportunity, were vast. Bern had over 80 publications, served as a journal and proceeding editor and reviewer, wrote dozens of reports, and gave many invited presentations at organized workshops, conferences, and seminars. Well known for his work with PICES and ICES, Bern also participated in many international conferences, organized and sponsored by American Fisheries Society/International Fisheries Section, and other organizations from many countries, including the United States, Mexico, Canada, Greece, China, Korea, Australia, Japan, Norway, the United Kingdom, Russia, as well as within the European Union. His peer group held him in the highest regard, and enjoyed the opportunity to collaborate, share research, and profit in personnel and career developments from this interchange. In addition to AFS, Bern was a member of the American Institute of Research Fishery Biologists, Australian Society of Fish Biology, Fisheries Society of the British Isles, and Sigma Xi.

In addition to that extensive list of accomplishments, Bern also contributed to the early development of the 1st World Fisheries Congress, and served in several roles as the Congress developed. Bern provided a continuity of professional involvement to the Congress, which significantly contributed to its continued evolution. He was active in organizing training and topical workshops, serving on executive and planning teams, as being an international representative for AFS/IFS, and was one of the key visionaries who helped AFS plan, organize, and win the bid to hold the 4th Congress in Vancouver, Canada in 2004, and served as Chair of the International Steering Committee. His contributions have helped make the World Fisheries Congress the success it is now and will continue to be in the future.

Closer to home, Bern served as a member of the AFS Editorial Board from 1991-1993. He was an active member of the Marine Fisheries Section, served as president of the IFS and Computer User Sections, and was instrumental in developing the goals of the sections. He was a key player in assisting with the formation and development of the Mexican Chapter, Western Division of AFS, as well as other AFS subunits. This long term goal of the IFS— recently realized—and the Mexican Chapter, continues to develop and flourish with assistance from individuals like Bern, and many other supporters throughout our society.

Bern's outgoing nature helped him make immediate friends, especially with those who enjoyed a good party, meals and camaraderie. He set a high standard of professional and personal presence, and his achievements will long be highly regarded regionally, nationally, and internationally by marine and other fishery science professionals. He will be missed.

Bern's family's preference is that, in lieu of flowers, donations be used to establish a fund to support travel and participation of students from various backgrounds, cultures, and countries in joint PICES/ICES activities. One recommendation is that the funding go to support the spring 2012 PICES/ICES Early Career Scientists Conference in Spain. Questions about donations can be addressed to Ms. Christina Chiu (Christina@pices.int) at the PICES Secretariat. To make a donation, please send checks (made out to PICES, USD, or CAD) or bank drafts (any currency) to:

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Glen Contreras

NEWS:
AFS UNITS

Northeastern Division Annual Meeting

The Northeastern Division (NED) held its annual meeting in conjunction with the 66th Northeast Fish and Wildlife Conference, April 25-27, 2010 at the Boston Newton Marriott Hotel in Newton, Massachusetts. This year's conference theme was "Climate Change and Wildlife Conservation—Adaptation and Mitigation". A highlight of the meeting was a special symposium on striped bass management featuring presentations by 15 speakers organized by Paul Perra, (NMFS) Gary Shepherd, Wilson Lane (USFWS), and Robert Beal (Atlantic States Marine Fisheries Commission). About 40 members attended the NED business meeting and were addressed by AFS President Don Jackson on recent and future initiatives by AFS. AFS First and Second Vice-Presidents Bill Fisher and John Boreman also attended the meeting. The NED gave out several awards at the meeting. Forrest Bonney was the recipient of the President's Award, Roy Miller was the recipient of the Meritorious Service Award, and the Diadromous Conference Committee, which was responsible for the 2007 International Diadromous Fishes Symposium and its resulting 2009 AFS publication, was the recipient of the Special Achievement Award.

At the conference Monday evening banquet, NED President Paul Perra presented Dr. Victor Crecco with the Dwight Webster Memorial Award, the NED's highest honor. Dr. Crecco was recognized for his many contributions in the areas of fisheries science and management on anadromous and marine fishes he worked on in the Northeast over several decades. Dr. Crecco currently holds the position of Program Specialist with the Connecticut Department of Environmental Protection.

William Whitmore of the University of Rhode Island won Best Student Paper Award for his presentation "A look ahead at catch shares and the future of New England groundfish management: Will ITQs follow sectors?" Yoichiro Kannowon won Best Student Poster entitled "Evaluating effects of water withdrawals and impoundments on fish assemblages in Connecticut streams."

The John Moring Student Travel Awards went to Justin Davis, a Ph.D. candidate at the University of Connecticut (Storrs), Department of Ecology and Evolutionary Biology, and Sara M. Turner, Master of Science candidate at the State University of New York (Syracuse), College of Environmental Science and Forestry.

AFS President Don Jackson addresses the Northeastern Division Business Meeting on Recent and Future AFS Initiatives.

Alex Haro Accepts the Northeastern Division Special Achievement Award for the Diadromous Conference Committee from Desmond Kahn.

Paul Perra Presents Dr. Victor Crecco With the Northeastern Division Dwight Webster Memorial Award.

CALENDAR:

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

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

More events listed at www.fisheries.org.

Dec 1-2		12th Flatfish Biology Conference	Westbrook, Connecticut	www.mi.nmfs.gov/flatfishbiologyworkshop.html
Dec 10-13		Fifth Shanghai International Fisheries and Seafood Exposition—The Best Opportunity to Explore Chinese Market	Shanghai, China	www.sifse.com
Dec 12- 15	AFS	North Central Division, joint with Midwest Fish and Wildlife Conference	Minneapolis, Minnesota	www.midwest2010.org
		2011		
Jan 13-16	AFS	Spring AFS Southern Division Meeting	Tampa, Florida	www.sdafs.org/meetings/meethome.htm
Jan 26-28		Aquaculture Association 41st Annual Trade Show and Conference	Bay City, Texas	Cindy Schmiid, tinnyroo@aol.com

NEW

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AFS 2010 Award Recipients

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Spring Gearhart,
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and
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AFS Staff

CARL R. SULLIVAN FISHERY CONSERVATION AWARD

Presented to an individual or organization for outstanding contributions to the conservation of fishery resources: Richard Roos-Collins, Natural Heritage Institute and Charlton Bonham, Trout Unlimited. They are honored for exceptional conservation leadership in the achievement of the agreement for allocation of water in the Klamath River basin that will allocate water, rewild rivers, restore endangered and threatened fisheries, and result in the largest dam removal project in American history.

AWARD OF EXCELLENCE

This award, one of AFS's most prestigious, is presented to an AFS member for original and outstanding contributions to fisheries science and aquatic biology. **Roy Stein,** Ohio State University.

Merging Our Deeper Currents

PRESIDENT'S FISHERY CONSERVATION AWARD
Presented for singular accomplishments or long-term contributions that advance aquatic resource conservation at a regional or local level. The Eglin Air Force Base, Natural Resources Section was selected for successfully implementing an ecosystem-based approach to restoring, conserving and managing aquatic natural resources on Eglin Air Force Base in northwestern Florida and helping the endangered Okaloosa darter.

MERITORIOUS SERVICE AWARD
Presented to an individual for loyalty, dedication, and meritorious service to the Society throughout the years, and for exceptional commitment to AFS's programs, objectives, and goals.Fred Harris, retired, North Carolina Wildlife Resources Commission.

WILLIAM E. RICKER RESOURCE CONSERVATION AWARD
Presented to an individual or organization for singular accomplishments or long-term contributions that advance aquatic resource conservation at a national or international level. William Walter Fox, Jr., World Wildlife Fund was selected for his advocacy for policies to protect and restore marine resources and critical habitats.

THE

EMMELINE MOORE PRIZE
The American Fisheries Society (AFS) has established a new award, named after the first female AFS president, Emmeline Moore (1927-1928), to recognize career achievement in the promotion of demographic diversity in the society. Christine M. Moffitt, University of Idaho.

ROBERT L. KENDALL
Best Paper - TAFS

Steelhead Life History on California's Central Coast: Insights from a State-Dependent Model

William H. Satterthwaite, Michael P. Beakes, Erin M. Collins, Davis R. Swank, Joseph E. Meerz, Robert G. Titus, Susan M. Sogard, and Marc Mangel

JOURNAL OF AQUATIC ANIMAL HEALTH

Expression Analysis of Selected Immune-Relevant Genes in Channel Catfish during Edwardsiella ictaluri Infection

Banu Elibol-Flemming, Geoffrey C. Waldbieser, William R. Wolters, Carolyn R. Boyle and Larry A. Hanson

NORTH AMERICAN JOURNAL OF AQUACULTURE

Effect of Photoperiod Advancement of Atlantic Cod Spawning on Egg Size and Biochemistry

Randy W. Penney, M. Jeanne Hart, P. Lynn Lush and Christopher C. Parrish

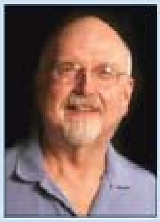
MERCER PATRIARCH BEST PAPER – NAJFM

A Simulation Study of the Effects of Spatially Complex Population Structure for Gulf of Maine Atlantic Cod

Danielle Ameen Reich and Joseph Thomas DeAlteris

GOLDEN MEMBERSHIP


Henry Booke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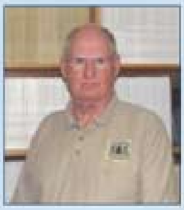
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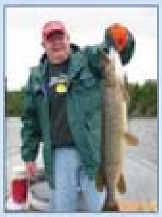
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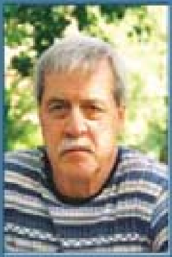
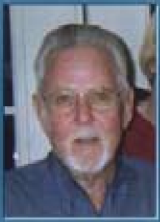
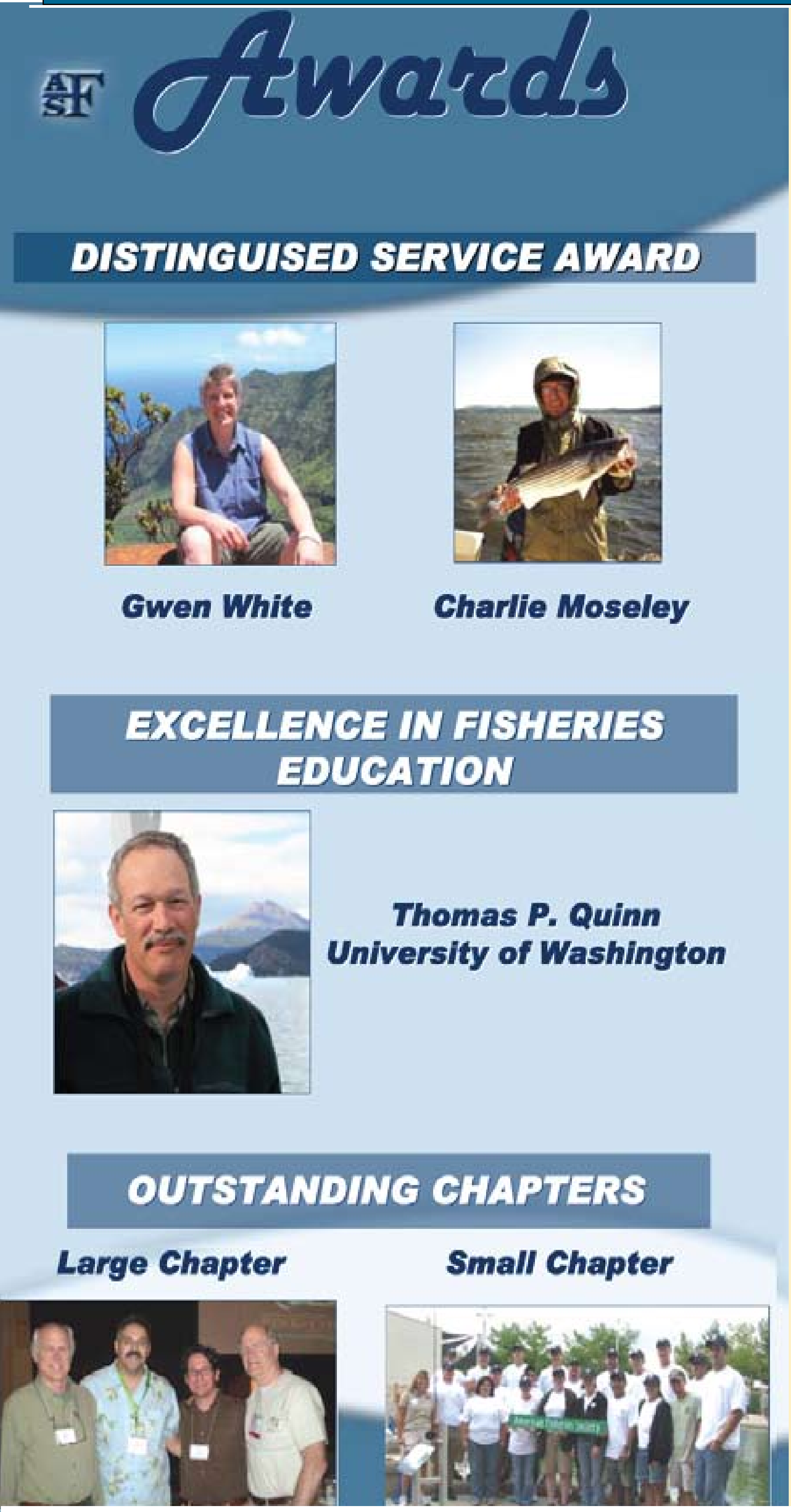

William Shelton


Clair Stalnaker


Arden Trandahl



AFS **Awards**

DISTINGUISED SERVICE AWARD

Gwen White

Charlie Moseley

EXCELLENCE IN FISHERIES EDUCATION

Thomas P. Quinn
University of Washington

OUTSTANDING CHAPTERS

Large Chapter

Small Chapter

POSTER: CHRISTINE MOFFITT

Golden Membership Awards

The Class of 1961
AFS Members for 50 years

ATTENDED

Bobby Grinstead

William Shelton

NOT IN ATTENDANCE

Henry Booke

Gerald Bouck

William Dieffenbach

Neal Foster

William Gould

Joe Herring

Donald Hoss

James Kempinger

James McCleave

Joseph Nelson

Roland Reagan

Clair Stalnaker

Arden Trandahl

Graden West

Society AFS Awards

JOHN E. SKINNER MEMORIAL SCHOLARSHIP WINNERS

Elissa Buttermore
NC State University

Michael Colvin
Iowa State University

Devin DeMario
Penn State University

Joshua Perkin
Kansas State University

Joshua Raabe
NC State University

Kelly Stockton
University of Idaho

Kenneth Riley
East Carolina University

Zachary Penney
University of Idaho

Michael Gatlin
Oklahoma State
University

Patrick Shirey
University of Notre Dame

SKINNER HONORABLE MENTIONS

Corey DeBoom
University of Illinois

David Janetski
University of Notre Dame

Bonnie Mulligan
S. Illinois University

Stephanie Shaw
SD State University

Catherine Murphy
Louisiana State University

J. FRANCES ALLEN SCHOLARSHIP

Marie-Ange
Gravel
Carleton
University

RUNNER UP

Neala W. Kendall
University of Washington

STUDENT WRITING

"Fishing with a Mission:
Collaborating to Monitor California's
Marine Protected Areas"

Erin Loury
Moss Landing Marine Labs

1st Runner Up:
Daniel James
SD State University

2nd Runner Up:
D.J. Dembkowski
Mississippi State University

STEVEN BERKELEY MARINE CONSERVATION FELLOWSHIP

Honorable Mention:

Justin Perrault
Florida Atlantic University

Kristina Camme
Duke University

Hollie Putnam
University of Hawaii at Manoa

OUTSTANDING STUDENT SUBUNIT

Lake Superior State University

POSTER: CHRISTINE MOFFITT

Additional photos from the meeting are available online at www.flickr.com/photos/americanfisheriessociety.

2010 AFS Section Awards

EQUAL OPPORTUNITIES SECTION

Mentor Award: Kelley D. Smith

Native People's Travel Award recipients:

Michael Gatlin, Oklahoma State University
Sam Matulich, Humbolt State University

EOS Travel Award winners:

Lubia Cajas Cano, University of Idaho
Marie-Ange Gravel, Carleton University, Ottawa, Ontario
Jessica Buelow, University of Idaho
Samantha Binion, East Carolina University Greenville, NC
Aloah Pope, University of Illinois, Urbana-Champaign

EDUCATION SECTION:

AFS Best Student Poster Award at the 2009 Annual Meeting In Nashville, Tennessee

Justin VanDeHey, "Nonlethal sampling of walleye and yellow perch for stable isotope analysis: a comparison of three tissues"

Honorable Mentions:

Christian Imholt, "Does the magnitude of diurnal temperature variability affect growth in juvenile Atlantic salmon?"

Clint Lloyd, "Examination of inter-specific competition between two bullhead catfishes."

AFS/Sea Grant Best Student Paper at the 2009 Annual Meeting In Nashville, Tennessee

Stacy Beharry, "Quantifying the value of nursery habitats by measuring survival using natural tags," Old Dominion University

Honorable Mentions:

Ryan Utz, " Variation in hydrological, chemical, and thermal responses to urbanization in streams between two physiographic regions of the southeastern United States," University of Maryland, Center for Environmental Science Appalachian Laboratory

Duncan Elkins, "The Effects of Rainbow Trout Introductions on Native Fishes in a Southern Appalachian Stream," University of Georgia, Warnell School of Forestry & Natural Resources

ESTUARIES SECTION

Student Travel Award:

Alicia Landi, University of Connecticut
Ken Riley, East Carolina University
Amy Then, College of William and Mary

Nancy Foster Habitat Conservation Award

Charles Rabeni

FISHERIES INFORMATION AND TECHNOLOGY SECTION

Best Student Poster Award at the 2010 Annual Meeting In Pittsburgh, Pennsylvania

Alicia Landi, "Estimation of wave energy using fetch and wind data at horseshoe crab spawning beaches along the Connecticut coast."

FISHERIES MANAGEMENT SECTION

Conservation Achievement award: Wildlife Forever

Award of Excellence: Michael Allen, Ken Bovee and Randy Schultz

Hall of Excellence: Fred Harris

Distinguished Service award: Fred Janssen

GENETICS SECTION

James E. Wright Award: Matthew Krampe and Michael Sovic

Stevan Phelps Memorial Award: Kenneth P. Currens, Carl B. Schreck, and Hiram W. Li for their paper, "Evolutionary Ecology of Redband Trout," in Transactions of the American Fisheries Society, 138:797-817.

MARINE FISHERIES SECTION

Steven Berkeley Marine Conservation Fellowship: Kristina Cammen

Honorable Mention: Justin Perrault and Hollie Putnam

Oscar E. Sette award: Michael H. Prager

Student Travel award:

Jay Dieterich, University of Southern Mississippi
Geoffrey Smith, University of Florida
Amy Koske, University of Massachusetts/Amherst
Kenneth Riley, East Carolina University

INTERNATIONAL FISHERIES SECTION

2010 Carl L. Sullivan Endowment Fund Travel Grant:

Jade Sainz-Garduno, (Marine Science and Limnology Institute, National Autonomous University of Mexico City, Mexico
Carla Ibanez Luna, University Mayor de San Andres in the Limnology Department, Cota Cota, Peru
Paulo dos Santos Pompeu, Fish Ecology Lab, Universidade Federal de Lavras, Brazil
Carlos Bernardo Mascarehas Alves, Universidad Federal de Minas Gerais, Belo Horizonte, Brazil

American Fisheries Society / Fisheries Society of the British Isles Membership Exchange Travel Award:

Ana Lewis, University of Southampton National Oceanography Centre, Southampton, UK
Marybeth Brey, North Carolina State University, Department of Zoology, North Carolina, US

PHYSIOLOGY SECTION

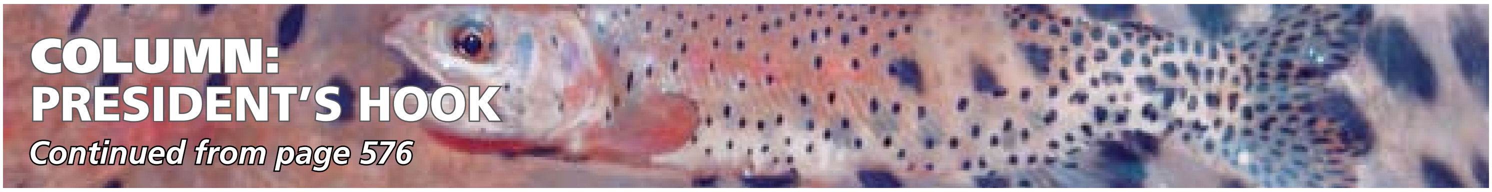
Award of Excellence: Steve F. Perry, University of Ottawa

9th International Congress on the Biology of Fish, 5-9 July 2010;Best student oral presentation:

Erika Eliason
2nd: Tammy Rodela
3rd: Christina Sørensen

Best student poster:

Yusuke Ito
2nd: Carlos F. C. Lanes
3rd: Eduardo Fuentes Jofré



COLUMN: PRESIDENT'S HOOK

Continued from page 576

Executive Director. After 60 days of posting, the RPC Chair and Executive Director consider the comments and may elect to request revision by the work group and RPC. The sponsor is advised of any revisions and provided opportunity for comment. Following member input and appropriate revision, the draft policy statement is forwarded by the RPC Chair to the Governing Board. A majority of the Governing Board is required to bring a policy statement to the AFS membership for a vote. If approved, the policy statement is voted on by the membership at the annual meeting or by electronic means. A majority approval is required for adoption of the policy.

Whew! What a process! Tremendous amounts of volunteer time are put in by sponsors, the RPC, work groups, members, and the Governing Board to promulgate a policy statement. It is long and it is tedious, but it assures that approved policy statements are credible, scientific documents that can be used as guides in decision making. The outcomes are strong documents providing sound guidance that support the AFS mission "to advance sound science, promote professional development, and disseminate science-based fisheries information for the global protection, conservation, and sustainability of fishery resources and aquatic systems."

But what do we do with policy statements once they are approved? They are loaded on the AFS website and are available for use. However, I am afraid that the electronic equivalent of forming mold in a corner of the basement often occurs. They are frequently forgotten about and not used to a great extent. As a Society we need to identify and adopt a more proactive stance on making use of our policy statements, especially the ones addressing important current issues. We need to make sure to initiate dialog between AFS and those formulating policies in major institutions having statutory authority for fisheries and aquatic resources. We need to raise awareness of our policy statements with broad distribution to agencies, legislators at all levels of government, NGOs, and the general public. Let's get moving and guarantee that our policy statements create influence. Give me your suggestions on how we can do a better job on this.

Standard Methods for Sampling North American Freshwater Fishes

Scott A. Bonar, Wayne A. Hubert, and
David W. Willis, editors

This important reference book provides standard sampling methods recommended by the American Fisheries Society for assessing and monitoring freshwater fish populations in North America. Methods apply to ponds, reservoirs, natural lakes, and streams and rivers containing cold and warmwater fishes. Range-wide and eco-regional averages for indices of abundance, population structure, and condition for individual species are supplied to facilitate comparisons of standard data among populations. Provides information on converting nonstandard to standard data, statistical and database procedures for analyzing and storing standard data, and methods to prevent transfer of invasive species while sampling.

284 biologists and managers from 107 agencies, universities, and businesses contributed to the book as authors, reviewers, or sponsors.

335 pages, hardcover, index
List price: $60.00
AFS Member price: $42.00
Item Number: 550.59C
Published August 2009

TO ORDER:
Online: www.afsbooks.org

American Fisheries Society
c/o Books International
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Herndon, VA 20172
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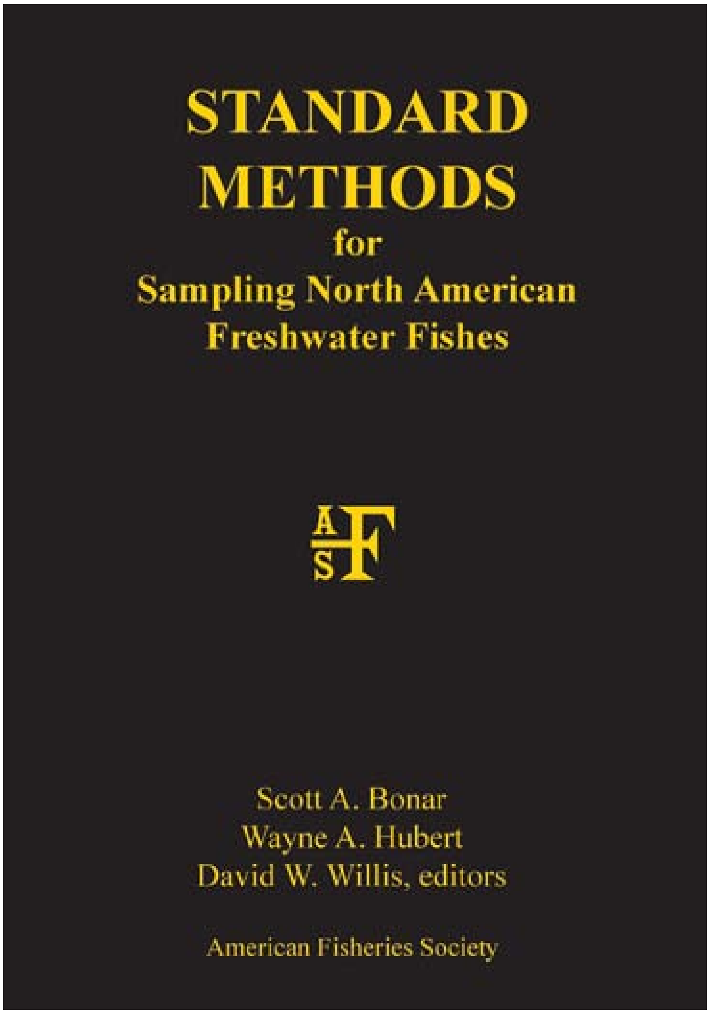
Fax: 703-996-1010



STANDARD
METHODS
for
Sampling North American
Freshwater Fishes

Scott A. Bonar
Wayne A. Hubert
David W. Willis, editors

American Fisheries Society

FINAL CALL FOR PAPERS AND SYMPOSIUM PROPOSALS FOR THE 141ST ANNUAL MEETING, SEPTEMBER 4–8, 2001 IN SEATTLE, WASHINGTON

Start planning your trip to Seattle for the AFS 141st Annual Meeting. Presentations and discussions at the meeting, "New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World," will focus on the huge challenges facing fishery resource managers today, and new and developing tools to help them meet those challenges. The meeting will be held September 4-8, 2011, at the Washington State Convention Center and neighboring Sheraton Hotel, in downtown Seattle. We look forward to seeing you in Seattle!

GENERAL INFORMATION

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

- Symposia,
- Contributed Papers, and
- Posters.

Oral presentations except a limited number of symposium presentations, will be limited to 20 minutes (15 minutes for presentation plus 5 minutes for speaker introduction and questions). All oral presenters are expected to deliver PowerPoint presentations. In keeping with the meeting's theme of new frontiers, for the first time at an AFS annual meeting, presentations can be uploaded online rather than in an A/V loading room. The loading room will be available, but online uploading is preferred. Further details will be provided to you by email after your submission is accepted.

AFS does not waive registration fees for presenters at symposia, workshops, or contributed paper sessions. All presenters and meeting attendees must pay registration fees. Registration forms will be available on the meeting website (http://www.fisheries.org/AFS2011) in May 2011; register early for cost savings.

SYMPOSIA

The Program Committee invites proposals for symposia. Topics must be of general interest to AFS members, and topics related to the meeting theme will receive priority. Symposium organizers are responsible for recruiting presenters, soliciting their abstracts, and directing them to submit their abstracts and presentations through the online submission page of the meeting website (http://www.fisheries.org/AFS2011). A symposium should include a minimum of 10 presentations and we encourage organizers to limit their requests to one-day symposia (about 20 oral presentations). Symposia with more than 20 presentations are strongly discouraged because of time constraints.

Traditionally, symposia have been dominated by oral presentations and sometimes supplemented by posters. If posters are part of a symposium, they can be complemented by "Speed Presentations," short oral presentations of poster highlights. This format elevates the profile of symposium posters, shortens the time required for symposia, and encourages interaction at the poster session. Speed presentations can be an effective way to disseminate information and foster one-on-one interactions among symposium participants and poster presenters. See Fisheries 32(12), p. 576 (available at http://www.fisheries.org/afs/docs/fisheries/fisheries_3212.pdf) for more information on this format.

Symposium proposals must be submitted online through the meeting website (http://www.fisheries.org/AFS2011) by 14 January 2011. You should receive email confirmation within a few days of submission. If you do not receive confirmation by January 21, 2011, please contact the Symposium Subcommittee (see contact information below). The Program Committee will review all symposium proposals and notify organizers of acceptance by February 11, 2011. If accepted, organizers must submit a complete list of all confirmed presentations and titles by March 4, 2011. Symposium abstracts (in the same format as contributed abstracts; see below) are due by March 11, 2011. We ask that symposium organizers ensure that all their session's abstracts are submitted. The submission software allows symposium organizers to easily monitor the status of their sessions.

Symposium presentations are generally limited to 20 minutes, but double time slots (i.e., 40 minutes) are allowed for keynote speakers. Speed presentations should be organized into blocks of 20 minutes (i.e., four five-minute presentations). Speed presenters are expected to submit abstracts by the March 11, 2011 due date. Please contact the symposium subcommittee chair if speed presentations are included in your symposium.

FORMAT FOR SYMPOSIUM PROPOSALS

(Submit using AFS online symposium submission form)

When submitting your abstract, include the following:

1. **Symposium title:** Brief but descriptive.
2. **Organizer(s):** Provide name, address, telephone number, fax number, and e-mail address of each organizer. Indicate by an asterisk the name of the main contact person.
3. **Description:** In 300 words or less, describe the topic addressed by the proposed symposium, the objective of the symposium, and the value of the symposium to AFS members and participants.

4. **Format and time requirement:** Indicate the mix of formats (oral and poster). State the time required for regular oral presentations (i.e., 20 minutes per speaker) and the time required for speed presentations and poster viewing (3 minutes per speaker plus 1 hour of poster viewing).
5. **Chairs:** Supply name(s) of individual(s) who will chair the symposium.
6. **Presentation requirements:** Speakers are required to use PowerPoint for presentations.
7. **Audiovisual requirements:** LCD projectors and laptops will be available in every room. Other audiovisual equipment needed for the symposium will be considered, but computer projection is strongly encouraged.
8. **Special seating requests:** Standard rooms will be arranged theatre-style. Please indicate special seating requests (for example, "after the break, a panel discussion with seating for 10 panel members will be needed").
9. **List of presentations:**
   Please supply information in the following format:
   Presenter's name:
   1. ______________________________
   2. ______________________________

Tentative title of presentation:
1. ______________________________
2. ______________________________

Confirmed : Yes/no
Format (regular or speed presentation):
1. ______________________________
2. ______________________________

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

Contributed Papers and Posters

The program committee invites abstracts for presentations for contributed paper and poster sessions. Authors must indicate their preferred presentation format:

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

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

Student Presenters

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

Abstract Submission

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

- 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.

FORMAT FOR ABSTRACTS

For Symposium Abstracts

(must be solicited by symposium organizer):

Enter Symposium title:
1. ______________________________
2. ______________________________

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

For Contributed Paper and Poster Abstracts

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

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

For All Abstracts, Format as in the Following Example

Title: An example abstract for the AFS 2010 Annual Meeting
Format: Oral
Authors:
Busack, Craig. NOAA Salmon Recovery Division, 1201 NE Lloyd Blvd., Suite 1100, Portland, OR 97232; 503/230-5412; craig.busack@noaa.gov
Ward, Dave. Columbia Basin Fish and Wildlife Authority, 851 SW Sixth Avenue, Suite 300 Portland, OR 97204; 503/274-7285; dave.ward@cbfwa.org
Presenter: Craig Busack
Abstract: Abstracts are used by the Program Committee to evaluate and select papers for inclusion in the scientific and technical sessions of the 2010 AFS Annual Meeting. An informative abstract contains a statement of the problem and its significance, study objectives, principal findings and application, and it conforms to the prescribed format. An abstract must be no more than 200 words in length.
Student presenter? No

Program Committee Contacts

Program Co-Chairs

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craig.busack@noaa.gov
503/230-5412
Dave Ward
Columbia Basin Fish and Wildlife Authority
dave.ward@cbfwa.org
503/274-7285

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WWW.FISHERIES.ORG/AFS2011

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ENDANGERED SPECIES

Atlantic Sturgeon vessel-Strike Mortalities in the Delaware Estuary. J. Jed Brown and Gregory W. Murphy. 35(2):72-83.

[Essay] **Problems Associated with Assessing the Status of Populations of Atlanticand Shortnose Sturgeons in the Southeastern United States.** Mark R. Collins. 35(7):340-341.

FISHERIES ADMINISTRATION

Environmental Review Approaches by Fish and Wildlife Agencies in the United States and Canada. Danielle R. Pender and Fred A. Harris. 35(7):332-339.

FISH HABITAT

[President's Hook] **A Foundation and Framework for Fisheries.** Donald C. Jackson. 35(2):56, 90.

A Novel Technique for Mapping Habitat in Navigable Streams Using Low-cost Side Scan Sonar. Adam J. Kaeser and Thomas L. Litts. 35(4):163-174.

Degradation in U.S. Reservoirs. L. E. Miranda, M. Spickard, T. Dunn, K. M. Webb, J. N. Aycock, and K. Hunt. 35(4):175-184.

[Director's Line] **No Habitat…No Fish.** Gus Rassam. 35(4):185.

The Challenges of Tracking Habitat Restoration at Various Spatial Scales. Katie Barnas and Stephen L. Katz. 35(5):232-241.

An Evaluation of Management Objectives Used to Assess Stream Habitat Conditions on Federal Lands within the Interior Columbia Basin. Jeffrey L. Kershner and Brett B. Roper. 35(6):269-278.

A Species Crediting Methodology that Supports Conservation Banking for an Endangered Floodplain Minnow. P.D. Scheerer and T. A. O'Neill. 35(6):280-291.

Linking Ecosystems, Food Webs, and Fish Production: Subsidies in Salmonid Watersheds. Mark S. Wipfli andColden V. Baxter. 35(8):373-387.

Sampling for Environmental Flow Assessments. John G. Williams. 35(9):434-443.

[President's Hook] **A Synergistic Multi-Directional Endeavor.** Donald C. Jackson. 35(1):4, 47.

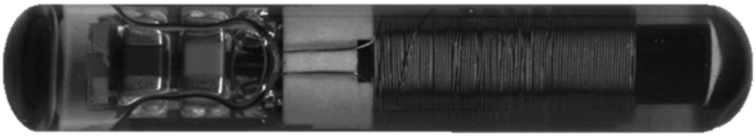
FISHERIES MANAGEMENT

[Essay] **Operating Hatcheries Within an Ecosystem Context Using the Adaptive Stocking Concept.** Todd N. Pearsons. 35(1):23-31.

[Student Writing Contest] **Are Robots and Satellites the Future of Fisheries Management?** Steven Gray. 35(1):48.

Piscicides and Invertebrates: After 70 Years, Does Anyone Really Know? Mark R. Vinson, Eric C. Dinger, and Deanna K. Vinson. 35(2):61-71.

[Essay] **Defining Overfished Stocks: Have We Lost The Plot?** Ray Hilborn



and Kevin Stokes. 35(3):113, 120.

[Students' Angle] **Excellence in Fisheries Management Made Possible by the Fenske Fellowship.** Heidi Ziegenmeyer. 35(5):248-249.

[Guest Director's Line] **A Biased Look Backward—A Myopic Look Forward.** Fred A. Harris. 35(7):342-343.

Implementation of Genetic Conservation Practices in a Muskellunge Propagation and Stocking Program. Martin J. Jennings, Brian L. Sloss, Gene R. Hatzenbeler, Jeffrey M. Kampa, Timothy D. Simonson, Steven P. Avelallemant, Gary A. Lindenberger, and Bruce D. Underwood. 35(8):388-395.

[President's Hook] **New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World.** Wayne A. Hubert. 35(9):420, 454.

FishSmart: An Innovative Role for Science in Stakeholder-Centered Approaches to Fisheries Management. Thomas J. Miller, Jeff A. Blair, Thomas F. Ihde, Robert M. Jones, David H. Secor, and Michael J. Wilberg. 35(9):424-433.

[President's Hook] **New Frontiers in Fisheries Management and Ecology: Defining Fisheries Management.** Wayne A. Hubert. 35(10):472, 510.

Different Approaches to Habitat Surveys Can Impact Fisheries Management and Conservation Decisions. Robert Al-Chokhachy and Brett B. Roper. 35(10):476-488.

[President's Hook] **New Frontiers in Fisheries Management and Ecology: AFS Leadership in Fisheries Education.** Wayne A. Hubert. 35(11):524, 566.

Conserving Peripheral Trout Populations: the Values and Risks of Life on the Edge. Amy L. Haak, Jack E. Williams, Helen M. Neville, Daniel C. Dauwalter, and Warren T. Colyer. 35(11):530-549.

[Essay] **California Golden Trout: Perspectives on Restoration and Management.** Edwin P. (Phil) Pister 35(11):550-553.

[Guest Director's Line] **Stewarding Piscicides as Tools in Fish Management: AFS's Role in Assuring Future Availability in a Changing World.** Brian Finlayson, Rosalie Schnick, and Don Skaar. 35(11):554-555.

[President's Hook] **New Frontiers in Fisheries Management and Ecology: AFS Leadership in Policy.** Wayne A. Hubert. 35(12):576, 616.

Similarities, Differences, and Unknowns in Biology and Management of Three Parasitic Lampreys of North America. Benjamin J. Clemens*, Thomas R. Binder, Margaret F. Docker, Mary L. Moser, and Stacia A. Sower. 35(12):580-596.

Fishermen Tag a Portion of Their Catch to Estimate Lobster Abundance. Robert J. Miller. 35(12):597-602.

FISHERIES RESEARCH

The Juvenile Salmon Acoustic Telemetry System: A New Tool. Geoffrey A. McMichael, M. Brad Eppard, Thomas J. Carlson, Jessica A. Carter, Blaine D. Ebberts, Richard S. Brown, Mark Weiland, Gene R. Ploskey, Ryan A. Harnish, and Z. Daniel Deng. 35(1):9-22.

Improving Inferences from Fisheries Capture-Recapture Studies through Remote Detection of PIT Tags. David A. Hewitt, Eric C. Janney, Brian S. Hayes, and Rip S. Shively. 35(5):217-231.

FISHERIES SCIENCE

Fisheries Education in the 21st Century: Challenges and Approaches to Training the Next Generation of Fisheries Scientists. Donald C. Jackson, Steven R. Chipps, and Michael L. Brown. 35(6):264, 301.

Potential Impacts of Docks on Littoral Habitats in Minnesota Lakes. Paul Radomski, Lyn A. Bergquist, Michael Duval, and Andrew Williquett. 35(10):489-495.

GENETICS

[Student's Angle] **Reflections on Student Involvement in the Genetics Section, the Parent Society, and Beyond.** Yen Duong and Jamie Roberts. 35(4):188-189.

INTRODUCED SPECIES

Aquatic Invasive Species Transport via Trailered Boats: What Is Being Moved, Who Is Moving It, and What Can Be Done. John D. Rothlisberger, W. Lindsay Chadderton, Joanna McNulty, and David M. Lodge. 35(3):121-132.

SOCIETY AND PROFESSIONAL ISSUES

[Guest Director's Line] **Looking forward with a 2020 vision.** Gus Rassam. 35(1):32.

[Guest Director's Line] **Unsustainable Global Fisheries Need a Unified Call for a UN Conference.** William W. Taylor, Abigail J. Lynch, and Michael G. Schechter. 35(2):84-85.

[Student's Angle] **The Fish Culture Section of AFS— Encouraging, Recognizing, and Rewarding Student Involvement.** Heidi A. Lewis. 35(2):86-87.

[President's Hook] **In Consideration of the Hypolimnion.** Donald C. Jackson. 35(3):108, 135.

[Guest Director's Line] **Hello from the Fish Culture Section!** Jesse Trushenski. 35(3):133, 134.

[Student's Angle] **Enhancing Graduate School Experience through Participation in Place-Based Education: A Case Study of the Cape Eleuthera Island School/ Cape Eleuthera Institute.** Karen J. Murchie, Aaron D. Shultz, and Edd J. Brooks. 35(3):140-141.

[President's Hook] **From water Strider to Diving Beetle: Challenges and Opportunities for Global Professionalism.** Donald C. Jackson. 35(4):160, 192.

[President's Hook] **Nurturing the Garden.** Donald C. Jackson. 35(5):212, 246.

Vision Unveiled for "Mosaic of Habitats" in the New York/ New Jersey Estuary. JoAnne Castagna. 35(5):213-214.

[Guest Director's Line] **Certification—Promoting the Importance of Fisheries Professionals.** Gail Goldberg. 35(5):242-243.

[Guest Director's Line] **Greetings from the Education Section!** Steven R. Chipps. 35(6):292, 295.

[President's Hook] **Addressing the Oil Spill in the Gulf of Mexico.** Donald C. Jackson. 35(7):316.

The Mining Law of 1872: Change is Overdue. Carol Ann Woody, Robert M. Hughes, Eric J. Wagner, Thomas P. Quinn, Leanne H. Roulson, Lori M. Martin, and Kitty Griswold. 35(7):321-331.

AFS Constitution and Rules: Proposed Amendments to the American Fisheries Society Constitution. Gus Rassam. 35(7):344.

[Student's Angle] **Faculty and Graduate Student Mentoring in the Hutton Junior Fisheries Biology Program.** Eric R. Larson. 35(7):350-351.

[President's Hook] **Engaging Deeper Currents.** Donald C. Jackson. 35(8):368, 408.

[Guest Director's Line] **A Behind-the-Scenes Look at the Dedicated Work of Our Members in Getting New Animal Drugs Approved for Use in Fisheries.** Carl Burger. 35(8):396, 409.

AFS 2009 Annual Report:Merging our Deeper Currents. Gus Rassam. 35(8):399-406.

[Guest Director's Line] **The AFS Young Professional Mentoring Program: Our Experience as the First Cohort of Mentees.** Tom Lang, Jeremy Tiemann, Felipe Amezcua, and Quinton Phelps. 35(9):444, 462.

[Essay] **Fisheries Education in the 21st Century.** Donald William Gabelhouse, Jr.. 35(9):445-448.

[Guest Director's Line] **First Joint TWS -AFS Symposium: Societies Address Introductions and Reintroductions.** Jerrold L. Belant, Peter J. Allen, Bruce D. Leopold, and Donald C. Jackson. 35(10):496-497.

[Essay] **Fisheries Education in the 21st Century. Distance Learning in Today's Classroom.** Andrew C. Seitz and Trent M. Sutton. 35(10):501-505.

[Guest Director's Line] **AFS Journal publishing moves into a new era.** Gus Rassam. 35(12):605.

ANNOUNCEMENTS: JOB CENTER

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

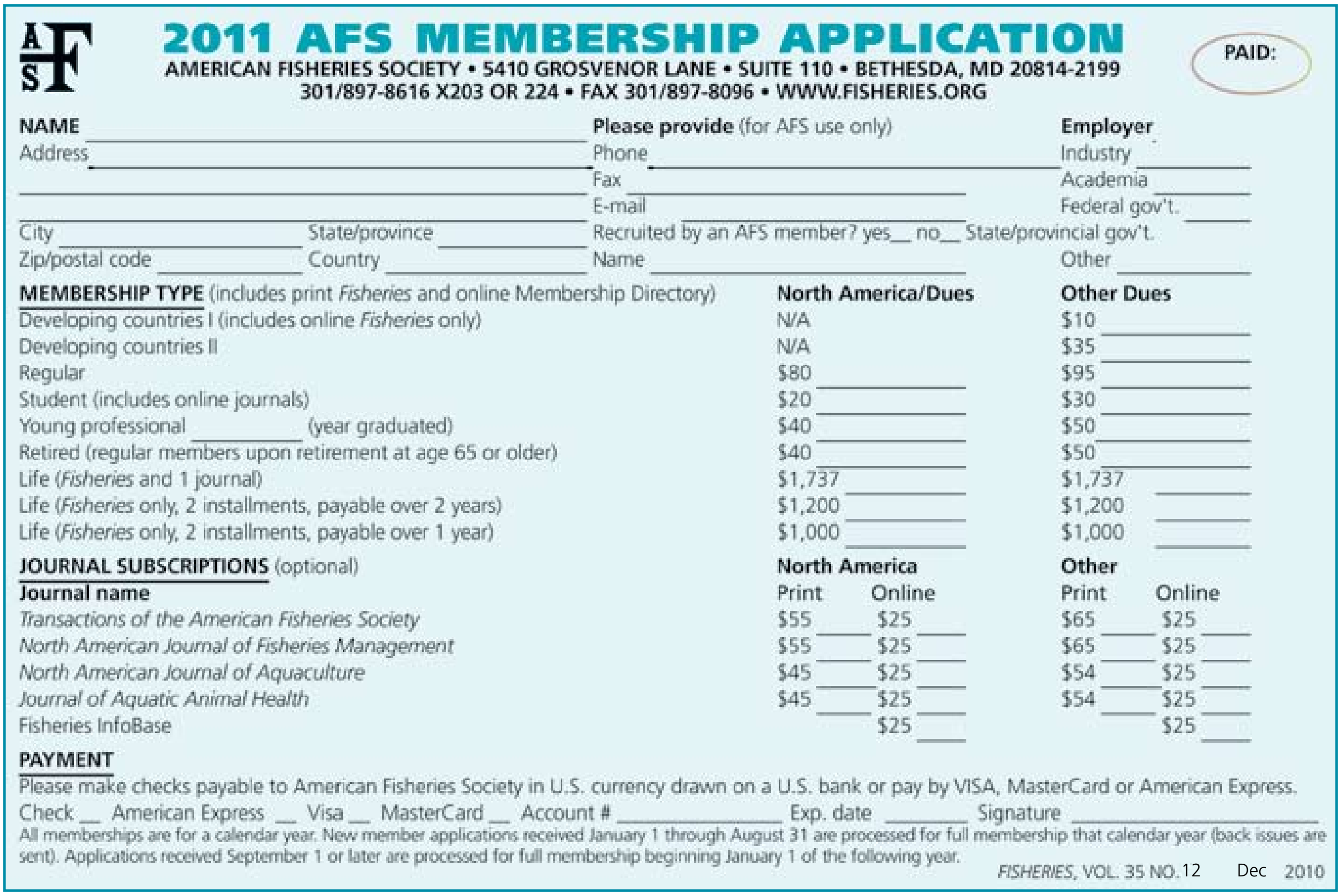
Quantitative Ecologist/Data Analyst, Normandeau Associates, Inc., New Hampshire.
Salary: Depends on experience.
Closing: 1 December 2010.
Responsibilities: Work independently and with project scientists to develop and manage project-specific databases, facilitate quality control/quality assurance of these data, and perform statistical and spatial analysis.
Qualifications: M.S. in applied statistics or biostatistics, with supporting formal training in ecology, fisheries, and aquatic ecology; or a M.S. in ecology, fisheries, or aquatic ecology with supporting formal training in applied statistics and biostatistics, and a minimum of three years experience, preferably in quantitative ecology. Possess a demonstrated knowledge of analysis software, including but not limited to SAS, MATLAB, GIS and the application of this software to describe patterns in biological and environmental data and test hypotheses concerning these data.
Contact: Send cover letter and resume to HR@normandeau.

Ph.D. Graduate Research Assistantship, North Carolina State University, Raleigh.
Salary: $19,000 per year 12 months, health insurance and full tuition and fees paid.
Start date: August 2011.
Responsibilities: . Project is focused on large-scale survey of the causes and consequences of intersex fish. This collaborative research project will be a mix of ecology, ecotoxicology, and fish biology, and will include field and laboratory components.
Qualifications: M.S. degree in biology, toxicology, fisheries, ecology, or related environmental science field. Exceptional students with a B.S. degree and appropriate experience will be considered . Experience in toxicology and/or analytical methods a plus, but not required. Admission is competitive selected students usually have GRE

scores 1200 and a GPA 3.5, though exceptions can be made for students with specific skills and experience.
Contact: Please e-mail a letter of interest, CV, and unofficial copies of GRE scores, and college transcripts to Greg Cope, greg_cope@ncsu.edu. See: http://www.ncsu.edu/project/fish-lab.

M.S. Graduate Assistantships, North Carolina State University, Raleigh.
Salary: Approximately $17,500 per year plus payment of health insurance, tuition, and fees.
Start date: August 2011.
Responsibilities: Available projects are focused on two issues: movement of coastal largemouth bass associated with habitat availability and hypoxia, and white bass life histories and movement patterns in inland reservoirs. Both projects are collaborative efforts with the North Carolina Wildlife Resources Commission and offer a mix of basic ecology and applied fisheries management.
Qualifications: Admission is competitive and successful applicants to our laboratory typically have GPA 3.5, GRE scores 1200, and at least some field or laboratory experience, though exceptions can be made. In addition, we re looking for students who are motivated, enthusiastic, and work well independently and in a large group.
Contact: E-mail a letter of interest, c.v., names of references, and copies of transcripts and GRE scores (official copies not necessary) to Derek Aday and Jim Rice at derek_aday@ncsu.edu and jim_rice@ncsu.edu. See http://www.ncsu.edu/project/fish-lab.

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



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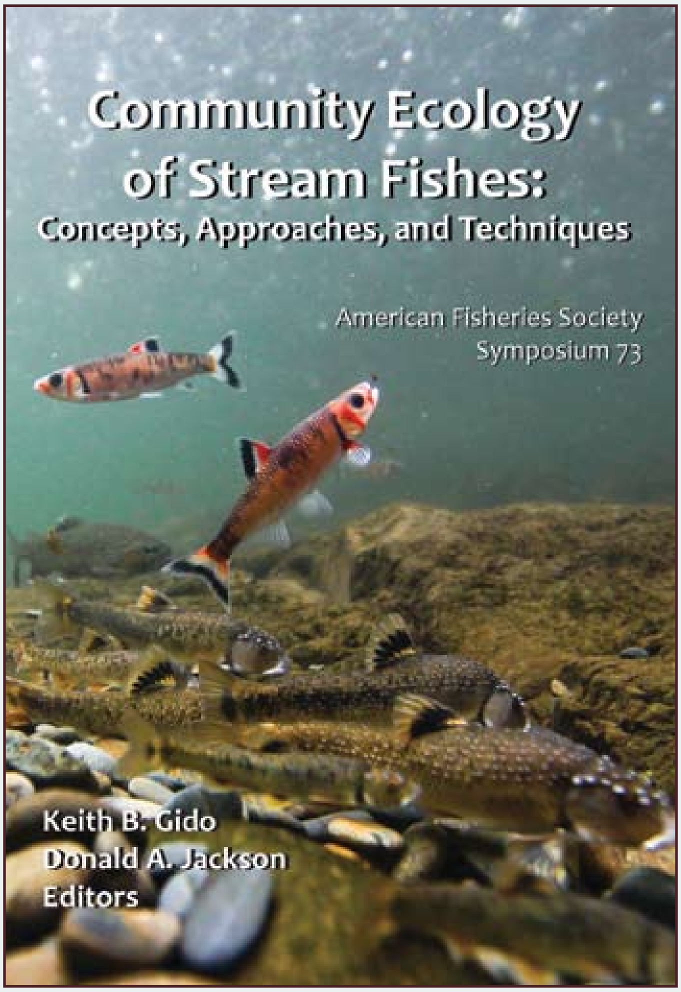
Community Ecology of Stream Fishes

Concepts, Approaches, and Techniques

Keith B. Gido and Donald A. Jackson, editors

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

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



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Concepts, Approaches, and Techniques

American Fisheries Society
Symposium 73

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Donald A. Jackson
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