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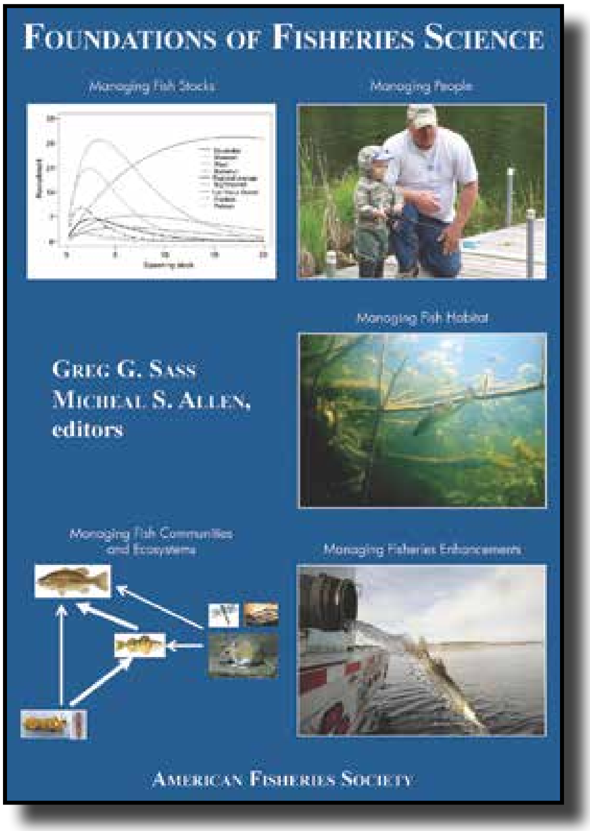
Foundations of Fisheries Science



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Foundations of Fisheries Science highlights the classic and critical works associated with fisheries management. With input from fisheries professionals and students from around the world, the editors selected 43 full-text articles along with 30 “honorable mention” citations (with associated abstracts) that have helped to mold the discipline of fisheries science. The selected articles were represented by 21 journals, ranging in discipline from fisheries, ecology, human dimensions, and others.

The book is organized into five sections (1. Managing Fish Stocks, 2. Managing People, 3. Managing Fish Habitat, 4. Managing Fish Communities and Ecosystems, and 5. Managing Fisheries Enhancements), which represent the critical components of fisheries (fish, humans, habitat) and the most common management approaches (regulations, stocking, habitat protection/restoration). Section editors provide insightful commentaries highlighting and summarizing the articles presented in each section.

Foundations of Fisheries Science can be used as a reference, or as a textbook to lead undergraduate and graduate courses and discussions.

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Cover: Nicholas E. Mandrak (left) and D. Andrew R. Drake (right) sampling baitfishes in Southern Ontario. Photo credit: Becky Cudmore.

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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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COLUMN
President's Commentary

Fisheries Ethics, or What Do You Want To Do with Your Scientific Knowledge in Addition to Earning a Living?

Bob Hughes, AFS President

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In its recent survey of fishery employers, AFS Special Committee on Educational Requirements found that there was a major gap between needed human dimensions expertise and student preparation in that area (Steve McMullin, Virginia Polytechnic Institute and State University, unpublished data). A key aspect of human dimensions is training in professional ethics. Like other professional societies, the Society has standards of professional conduct expected of all members (American Fisheries Society 1997). Three of those standards bear repeating here: (1) clearly separate professional opinion from accepted knowledge or fact in all communications; (2) reject attempts by employers and others to coerce or manipulate professional judgment and advice; and (3) expose scientific or managerial misconduct, including misrepresentation to the public of aquatic science/professional information, by informing the Society president. However, as discussed in Hughes (2014), iron triangles hinder individual implementation of such standards because of substantial pressures from employers, grant sources, and affected industries.

D. L. Bottom (1992) argued that natural resource management involves much more than purely scientific or technological issues because it involves ethical and values considerations regarding how humans relate to the rest of nature. For natural resource professionals, he asked what our ethical responsibilities to the ecosystems or resources we study or "manage" are, as well as to the organizations we represent, and to the current public, and to future generations.

I contend that our first responsibility should be to protect the resource in a sustainable manner. If we fail to do that, current and future generations, as well as our employers and professional societies, will suffer. Like the physicians' Hippocratic Oath, our first obligations are to our patients—the natural resources. Such protections involve a focus on sustaining ecosystem integrity, with humans as ecosystem stewards versus short-term economic and politically expedient (utilitarian) exploiters (Leopold 1947; Pister 1992; Karr 2009). Of course, ethical treatment of resources also includes ethical treatment of study organisms.

We also have obligations to the public to provide accurate, unbiased information—both to those who depend on the resources that we manage for their living, sustenance, and recreation, as well as to the taxpayers who are supporting our salaries and benefits directly or indirectly. The public needs both our scientific information and our professional opinions (clearly distinguished). Such information and opinions need presentation in scientific publications for review and criticism by scientists, but they also need presentation in nonscientific media where they can be made understandable to educated nonscientists.

Sustainable management of natural resources encompasses sincere obligations to future generations because degraded resources (like government debts and climate change impacts) are transferred from current to future generations. Obligations to future generations are clearly incorporated in U.S. federal law (e.g., National Environmental Policy Act 1969) and in state law (e.g., Oregon Revised Statutes 2011). In addition to legal reasons for concerning ourselves with future generations, Boulding (1970) felt that a society's long-term welfare is determined by how well current citizens identify with their society spatially and temporally (including the future). Partridge (1992) explained that future generations offer continuity for the things we appreciate and life-transcending meaning for our own existence.

Sometimes our obligations to inform the public and our profession may directly conflict with our employer's decisions and obligations.

We clearly have ethical obligations to our employers and funding institutions, but sometimes our obligations to inform the public and our profession may directly conflict with our employer's decisions and obligations. Lichatowich (1992) wrote that employees tend to feel pressured by employers to be team players and conform to upper-level decisions with which they disagree. But true teams include individuals with differing perspectives and knowledge gathered to attain common objectives (Lichatowich 1992). He felt that it is desirable to disagree with one's supervisor (in an appropriate manner) and that the intensity of the team player syndrome reduces an institution's strength and leadership potential. Bella (1992) determined that it is normal institutional behavior to develop and promote assessments or decisions that select information favorable to the managers of those institutions in the short term. He found that conflicting data and interpretations are screened out, those presenting such information are deemed troublemakers, and only supporting information is passed on to higher levels of management. These systemic distortions of information exist in all

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COLUMN
Policy

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Shall We Advocate?

Thomas E. Bigford, AFS Policy Director

Advocacy in its simplest construct has two components—an issue and a voice. Life is rarely so simple, as is definitely true about advocacy. AFS is actively engaged in that debate as we consider roles that may position us to be a stronger advocate for our needs and for the fish. So how do we proceed? Can debate lead to a decision in our near future?

Fortunately for our collective interests, AFS can call on more than 8,500 members, dozens of units arranged by geography and specialty, and connections to literally hundreds of universities, businesses, and government agencies throughout North America, with more overseas. Many of those potential partners are well versed in timely issues as disparate as recreational fishing, population dynamics, or resource economics. Together, AFS is well positioned to identify the issues, prepare spokespeople, and be powerful advocates.

We must not underestimate the importance of this opportunity. To advocate or not will occupy us for months. And that will be time well spent. We can construct a list of priorities by reviewing recent AFS publications or the Annual Meeting programs from Little Rock or Québec City. If we choose to advocate, the top 10 issues, which usually shift slightly each year, could occupy us for years as we analyze the best available science, develop solutions, seek public acceptance, and take action. Advocacy can strengthen our voice, which is imperative given the gravity of our work.

Advocacy also can be divisive. Some AFS members may feel it's not our role. We provide information, whether science or management. Others can focus on the communications end of our fields. One point worth noting: advocacy need not have the tainted reputation ascribed by some. We can advocate for fish, for natural and social science, for an ecosystem approach. To me, being an advocate means using our knowledge to best advantage. One antonym would be spectator, and that is unlikely to serve us well.

AFS has contemplated an advocacy role before. We approached the issue in 1991–1992 when then-AFS President Richard Gregory established a Task Force on Advocacy, chaired by Jerry Clark. Gregory's timely effort was frustrating, as revealed in a memo from his successor, AFS President Carlos Fetterolf (1992–1993). Other writings associated with that effort suggest a strained process and perhaps complacent members, but they tried. AFS made little progress in those first 2 years. Hopefully we'll have a more robust debate this time around.

With a touch of incredibly good fortune, I was handed a copy of Fetterolf's memo as I was writing this column, recently freed from the AFS vaults by Howard Williams in the Society's office. One excerpt from the 22-year-old memo struck me:

> *The question of advocacy is burning up the Society. In every survey we take, the vast majority want AFS to be an advocate for fishery resources. The points of fire are where to place ourselves along the continuum between fervid and apathetic, who we join forces with or whether we should act alone, and how far we stray from the science base, if at all!*

That effort in the early 1990s, with support from two Presidents, didn't shake our priorities as much as some expected. At the same time, it probably met the desires of others. The Task Force on Advocacy continued its work in 1993–1995 but didn't result in lasting change. No doubt some individuals were outspoken advocates, and perhaps some members fled when their Society took a strong position, but AFS doesn't appear to have rallied around any unifying topics or asserted a central role commensurate with our membership and leadership.

Then-President John Boreman (2013) raised the issue again with his final "President's Hook" last August. He challenged us to reopen the discussion. Perhaps now is a better time. Our Governing Board dedicated much of its January 2014 meeting to the issue. For me, listening to the debate in the weeks before I joined the AFS staff as Policy Director was nothing short of inspiring. I couldn't help but see many parallels between our situation and another faced by one of the greatest advocates for our issues.

I find it interesting that our Society's consideration coincides with the 50th anniversary of Rachel Carson's death. Although ecological advocacy was still nascent when Carson emerged as a biologist/writer with the U.S. Fish and Wildlife Service in 1947, I have been struck by her early commitment to "conservation in action" through informed science and appropriate persistence. Threads of environmental activism, deep commitments, and precautionary principles have matured to varying extents since Carson's day, leaving ample inspiration for all of us, especially those of us contemplating our role as budding advocates.

Recall my simple recipe for successful advocacy. Not every Society member need be a world-renowned expert or riveting public spokesperson, but with the assets of our Society, we can create those pairings and increase our impact. Your Governing

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Little Chubs Migrate, Too

Walters, D. M., R. E. Zuellig, H. J. Crockett, J. F. Bruce, P. M. Lukacs, and R. M. Fitzpatrick. 2014. Barriers impede upstream spawning migration of Flathead Chub. *Transactions of the American Fisheries Society* 143:17–25.

Photo credit: Missouri Department of Conservation.

When you think of migrating fish, usually silvery salmon gracefully leaping up waterfalls in the Pacific Northwest come to mind. In fact, many freshwater fish migrate in order to spawn, even the small minnows and chubs of the large, muddy rivers of the Great Plains. These large rivers are now interrupted by numerous dams, diversion structures, and dewatered channels, which are thought to be a key factor in the decline of many plains fish species. But how do you prove that a small fish in a muddy river actually migrates? In a recent article in the Transactions of the American Fisheries Society, a team of scientists from the U.S. Geological Survey and Colorado Parks and Wildlife attempted to see whether an imperiled species, the Flathead Chub, migrates upstream to spawn in Fountain Creek, Colorado. The outcome would influence the construction of a fishway at a diversion dam on the creek. More than 10,000 chub were captured at various sites along the creek, marked, and released. During the summer spawning season, five times as many chub were found at the bottom of the dam than at other sites along the river. Of more than 6,000 fish captured and marked at the dam site, only 10 were recaptured upstream of the dam. Because this diversion structure is the obstacle farthest downstream of the 29 potential barriers on Fountain Creek, the authors note that a fishway there will produce the greatest benefits for Flathead Chub.

How Do Fish Catch a Virus? They Eat It

Getchell, R. G., E. R. Cornwell, G. H. Groocock, P. T. Wong, L. L. Coffee, G. A. Wooster, and P. R. Bowser. 2013. Experimental transmission of VHSV genotype IVb by predation. *Journal of Aquatic Animal Health* 25:221–229.

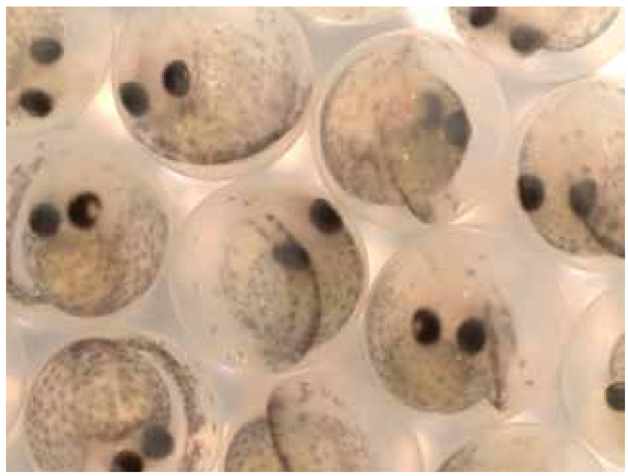

Photo credit: NOAA.

Viral hemorrhagic septicemia virus (VHSV) is just as unpleasant as it sounds for fish, leading to considerable losses of fish both in the wild and at some European fish farms. Unfortunately, this disease has recently spread to the Great Lakes region, but scientists are still unsure how it is transmitted. In a recent paper in the *Journal of Aquatic Animal Health*, researchers at Cornell University tested the idea that perhaps the virus can be transmitted when fish eat infected fish. The scientists fed VHSV-positive Fathead Minnows or Round Gobies to Tiger Muskellunge and compared their infection rate to other Tiger Muskellunge who just shared water with infected fish for 30 minutes or were fed uninfected minnows. Though 6 out of 16 Tiger Muskellunge who ate infected Fathead Minnows caught the virus, only 1 out of 16 Tiger Muskellunge who shared water with infected minnows tested as positive, and none of the Tiger Muskellunge fed uninfected minnows were positive. The only similar studies were performed back in the 1980s, when VHSV-infected pike fry were fed to adult pike and 30% of them died within two weeks. No Tiger Muskellunge caught VHSV from the Round Gobies, possibly because they were infected with a much lower dose of the virus. The authors conclude that predation of baitfish like minnows may be a significant factor in transmission of VHSV and its continued persistence in the Great Lakes ecosystem.

Venting Deepwater Fish: What Do Anglers Think?

Scyphers, S. B. F., J. Fodrie, F. J. Hernandez, Jr., S. P. Powers, and R. L. Shipp. 2013. Venting and reef fish survival: perceptions and participation rates among recreational anglers in the northern Gulf of Mexico. *North American Journal of Fisheries Management* 33:1071–1078.

As the fisheries science community debates the practice of "venting" bloated fish brought up deep, ocean waters before release, most marine anglers dutifully carry syringes in their tackle boxes. To vent a fish, anglers insert a hollow syringe into the fish's abdomen to release the expanded gases in the swim bladder or abdominal cavity, making it easier for the fish to return to the depths. But how many anglers actually vent their unwanted fish and do they think that it helps? In a recent article in the *North American Journal of Fisheries Management*, scientists surveyed 604 Alabama recreational fishing license holders and fishing tournament participants. About two thirds of anglers vented their fish and most perceived that venting does help fish survival. However, many anglers did not know where to properly insert the syringe and years of experience fishing had little effect on their expertise. The authors note that given the scientific uncertainty regarding the effectiveness of venting, anglers should be considered in the debate and efforts taken to avoid losing their trust in fisheries management regulations.

Photo credit: Harte Research Institute.

Fisheries Ecosystems and Hypoxia: A Future Informed by the Past

Sarah Moffitt

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The California Current Ecosystem (CCE) contains some of the most productive marine fisheries in the world. As global climate moves outside the established range of historical precedent, the physical structure of this ecosystem is shifting precipitously. Rapid change to environmental states that have no analogue in modern history is confounding to ecosystem scientists and managers: How do we plan for and manage ecosystems that are configuring to physical, chemical, or biological states that we have never seen or measured before? These environmental challenges require the incorporation of new toolkits, especially when managing resources that have such a direct impact on human economic vitality and traditional livelihoods such as marine fisheries.

Large-scale physical processes uniquely structure the CCE. Equatorward winds and the Coriolis Effect drive surface waters offshore and suction deeper water upwards along the shallow continental margin. This physical process seeds surface ecosystems with nutrients from the deep ocean; in a sense, upwelling fertilizes surface waters, much like you would fertilize your own garden to increase plant productivity. These nutrients drive spectacular surface blooms, which in turn support extensive and productive fisheries (e.g., salmon, rockfish, pandalid shrimp, and Dungeness crab) and large cetacean, pinniped, and seabird populations.

Surface productivity (i.e., algal blooms, organismal body parts, fecal matter, etc.) has to go somewhere, and it does—it sinks down through the water column. Bacteria in deeper, darker waters, where photosynthesis and thus oxygen replenishment can no longer occur, consume the surface-derived carbon. These microbial communities that feed upon the surface carbon rain consume dissolved oxygen for their respiratory requirements and, therefore, the greater the surface export of carbon, the greater the oxygen consumption at depth. These zones of acute oxygen consumption, and thus lowered dissolved oxygen concentrations, are called "oxygen minimum zones" (OMZs). They are essentially the low-oxygen shadow of the adjacent productive surface ecosystems, with upper and lower boundaries that delineate three-dimensional ecosystems and physical barriers. OMZs create substantial physical boundaries within fisheries ecosystems; fish and crustaceans are especially intolerant of low-oxygen conditions and exhibit avoidance behaviors of only mildly hypoxic waters.

The most recent deglaciation (18,000–10,000 years ago), an event of ~3.5°C of global warming and ~120 m of sea level rise, is an ideal laboratory to ask questions regarding how marine fisheries ecosystems undergo dramatic physical reorganization during events of global climate change. Deglaciation in the CCE, an event only a blink of an eye ago in the geologic past, can be investigated using shallow sediment cores from the continental margin. These sediment archives, much like tree rings or ice cores, reconstruct environmental and climatic change. Paleoceanographers use geochemical, microfaunal, or sedimentary toolkits to ask questions of these archives and to build cohesive chronologies that can be compared to other types of climate archives from distant parts of the globe. Though the deglaciation is not analogous to how we humans are currently changing the planet, it is nonetheless a rich source of data for how marine ecosystems are disturbed through rapid global warming. OMZs leave striking evidence in sediment archives of their presence; therefore, it is relatively easy to assess where, both geospatially and vertically, OMZs impinged upon the continental margin. Marine sediment cores provide clear warning of how rapidly and comprehensively oceanographic change can occur. Globally, the upper ocean (i.e., the primary location of the majority of fisheries ecosystems) rapidly lost dissolved oxygen during the deglaciation event, with heretofore unknown consequences to upper surface ocean ecosystems (Jaccard and Galbraith 2012). The catastrophic melting of North American ice sheets occurred at ~14,700 years ago, coincided with very rapid warming, and serves as the best analogue for what is occurring in the twenty-first century. During this event the continental margin of the CCE rapidly deoxygenated; from ~1,100 to 300 m below sea level, the water column became severely hypoxic (Moffitt et al. 2014). Therefore, this recent event of global warming was accompanied in the CCE by the deoxygenation of greater than 900 m of the water column.

What OMZs and the physical structure of the CCE mean for fisheries is this: there is a finite volume between the surface ocean and the upper boundary of the OMZ where oxygen-dependent fisheries ecosystems can flourish. In the modern CCE, this upper boundary of OMZ waters sits at ~600 m water depth. However, the key for fisheries planning in a nonanalogue future is that this low-oxygen boundary is not static. Already, modern anomalous events of severe upwelling-driven hypoxia have been documented on the continental shelf of the CCE (Chan et al. 2008), causing ecosystem-level disturbances and mass die-offs of fish and invertebrates (Grantham et al. 2004). Investigations of the recent deglaciation show that the CCE OMZ can expand vertically by hundreds of meters on decadal timescales, rapidly compressing oxygenated shallower water and volumetrically reducing fisheries ecosystems (Moffitt et al. 2014). Climate models reveal that deoxygenation of the surface ocean is an inherent component of a rapidly warming planet (Keeling et al. 2010). For fisheries, this means that, among the panoply of current ecosystem threats, from ocean acidification and coastal degradation to invasive species, expanding OMZs and the compression of oxygenated surface waters should be of primary concern to CCE fisheries managers. It also means that as habitat volume is reduced, the potential fisheries take from that habitat will be reduced, with downstream effects on fishing communities and coastal economies. The fishing communities of the North American coastline, already beleaguered by decades of fisheries closures and reductions, should be informed of how their livelihood is at risk in a future of rapid climate warming. OMZ expansion not only degrades potential fisheries habitat but removes that habitat from fisheries use; no oxygen means no fisheries, plain and simple.

Interactions between climate, upwelling systems, and fisheries ecosystems are critical to understanding how sustainable CCE fisheries will be in a warm, carbon-rich future. Ocean, climate, and fisheries scientists all bring critical knowledge of this system to bear and these sometimes disparate fields of study need to foster intellectual connections to meet the resource management and scientific needs in the coming century.

REFERENCES

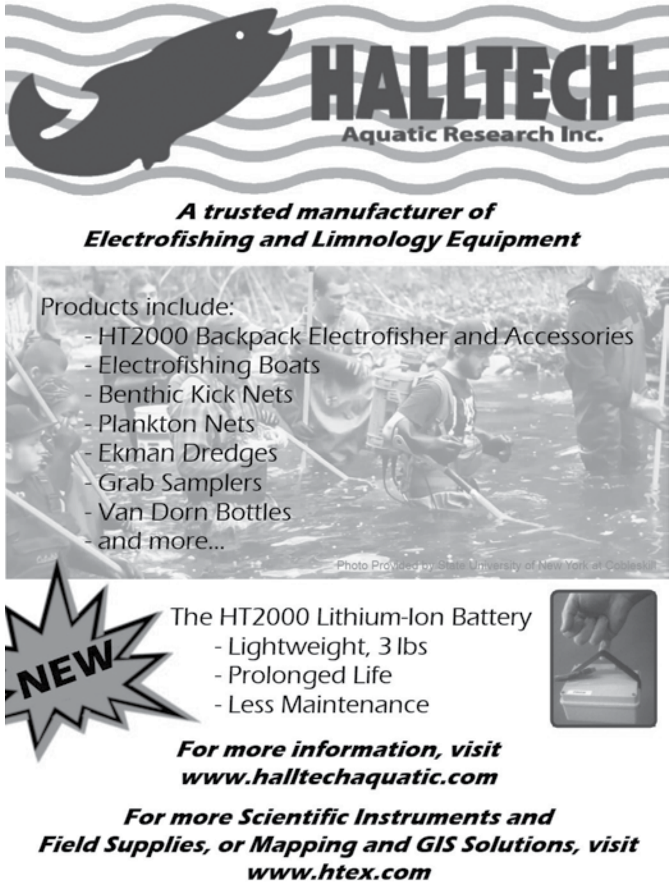
Chan, F., J. A. Barth, J. Jubchneco, A. Kirincich, H. Weeks, W. T. Peterson, and B. A. Menge. 2008. Emergence of anoxia in the California Current large marine ecosystem. Science 15:920.

Grantham, B. A., F. Chan, K. J. Nielsen, D. S. Fox, J. A. Barth, A. Huyer, J. Lubchenco, and B. A. Menge. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. Nature 429:749–754.

Jaccard, S. L., and E. D. Galbraith. 2012. Large climate-driven changes of oceanic oxygen concentrations during the last deglaciation. Nature Geoscience 5:151–156.

Keeling, R. F., A. Körtzinger, and N. Gruber. 2010. Ocean deoxygenation in a warming world. Annual Review of Marine Science 2:463–493.

Moffitt, S. E., T. M. Hill, K. Ohkushi, J. P. Kennett, and R. J. Behl. 2014. Vertical oxygen minimum zone oscillations during the last 20 ka in Santa Barbara Basin: a benthic foraminiferal perspective. Paleoceanography 29:49–57.



Ecological Risk of Live Bait Fisheries: A New Angle on Selective Fishing

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ABSTRACT: *The use of live baitfish is a cultural norm in many jurisdictions across North America. Because baitfish are often harvested from mixed stocks in the wild, the potential for bycatch exists, leading to the inadvertent relocation of nontarget species via distribution networks and anglers; therefore, like many fisheries, core issues revolve around selective fishing. We assess selectivity of bait fisheries in Ontario, focusing on the prevalence of bycatch within the commercial supply chain and the propensity for nontarget species introductions by anglers. Selection for target stocks was strong; however, species assemblages in retail tanks and angler purchases included game, imperiled, invasive, and other nontarget species. The combination of bycatch, a large volume of angling trips, and risky angler behavior results in high probabilities of introducing the suite of nontarget species contained incidentally. Pathway approaches to management provide opportunities to increase selectivity, manage the risk of species introductions, and sustain the integrity of bait operations throughout North America.*

Riesgo ecológico de pesquerías con carnada: un nuevo enfoque de pesca selectiva

RESUMEN: *el uso de carnada viva es una norma cultural en varias jurisdicciones de Norte América. Debido a que los peces que se utilizan como carnada a veces son capturados junto con una mezcla de stocks silvestres, existe el potencial de que se vuelvan fauna de acompañamiento, lo que tiene como consecuencia que especies no objetivo sean reubicadas de forma inadvertida a través pescadores y de redes de distribución; por esta razón, como sucede en muchas pesquerías, el problema medular gira en torno a la pesca selectiva. En este trabajo se evalúa la selectividad de las pesquerías de carnada en Ontario, Canadá, haciendo énfasis en la prevalencia de la fauna de acompañamiento en la cadena productiva y en la propensión que existe por parte de los pescadores a reubicar especies no objetivo. La selectividad que existe para los stocks objetivo es intensa, sin embargo las asociaciones de peces que comercializan los pescadores incluyen especies de pesca deportiva, especies en peligro, especies invasivas y otras especies no objetivo. La combinación de fauna de acompañamiento, una enorme cantidad de viajes de pesca y un comportamiento riesgoso por parte de los pescadores, da como resultado una alta probabilidad de introducir una amplia gama de especies no objetivo que son contenidas incidentalmente. El manejo utilizando corredores, podría incrementar la selectividad, controlar la introducción de especies y mantener la integridad de las operaciones pesqueras con carnada a lo largo de Norte América.*

INTRODUCTION

Angling in freshwaters constitutes a substantial recreational pursuit throughout North America, with annual average participation in Canada and the United States of greater than 3.01 and 27.5 million resident anglers each year, respectively (U.S. Department of the Interior et al. 2011; Department of Fisheries and Oceans Canada [DFO] 2012). These individuals spend approximately 40.1 (Canada) and 455.9 (United States) million days fishing, with greater than C$2.9 billion and US$25.7 billion in fishing-related expenditures, annually (U.S. Department of the Interior et al. 2011; DFO 2012). Given high rates of participation throughout much of North America, angling has significant social, ecological, and economic implications. Angling with live baitfish is prominent, with the majority of live bait harvest, culture, and use by anglers occurring in freshwaters within certain eastern Canadian provinces and many Midwest and Southern states. The nature of baitfish activity varies across jurisdictions according to local regulations (Dunford 2012; Figure 1). Litvak and Mandrak (1993) conservatively estimated the value of the North American live baitfish industry at US$1 billion annually. The retail value of baitfish sales for Michigan waters alone was greater than US$5.7 million in 2012, with a minimum wholesale value of US$900,000 (Gary Whelan, Michigan DNR, Fisheries Division, personal communication), and retail sales from the Ontario industry were recently estimated at C$14 million (Ontario Ministry of Natural Resources [OMNR] and Bait Association of Ontario [BAO] 2006). Baitfish culture exists where feasible and profitable, with 257 farms or culture facilities operating within the United States in 2005 (U.S. Department of Agriculture 2005; Figure 1). Arkansas is the largest contributor of cultured baitfish, housing 51 farms with 2005 sale values of approximately US$20 million (U.S. Department of Agriculture 2005).

Commercial baitfish operations, such as harvesting from the wild, culturing, wholesaling, and retailing live bait, provide

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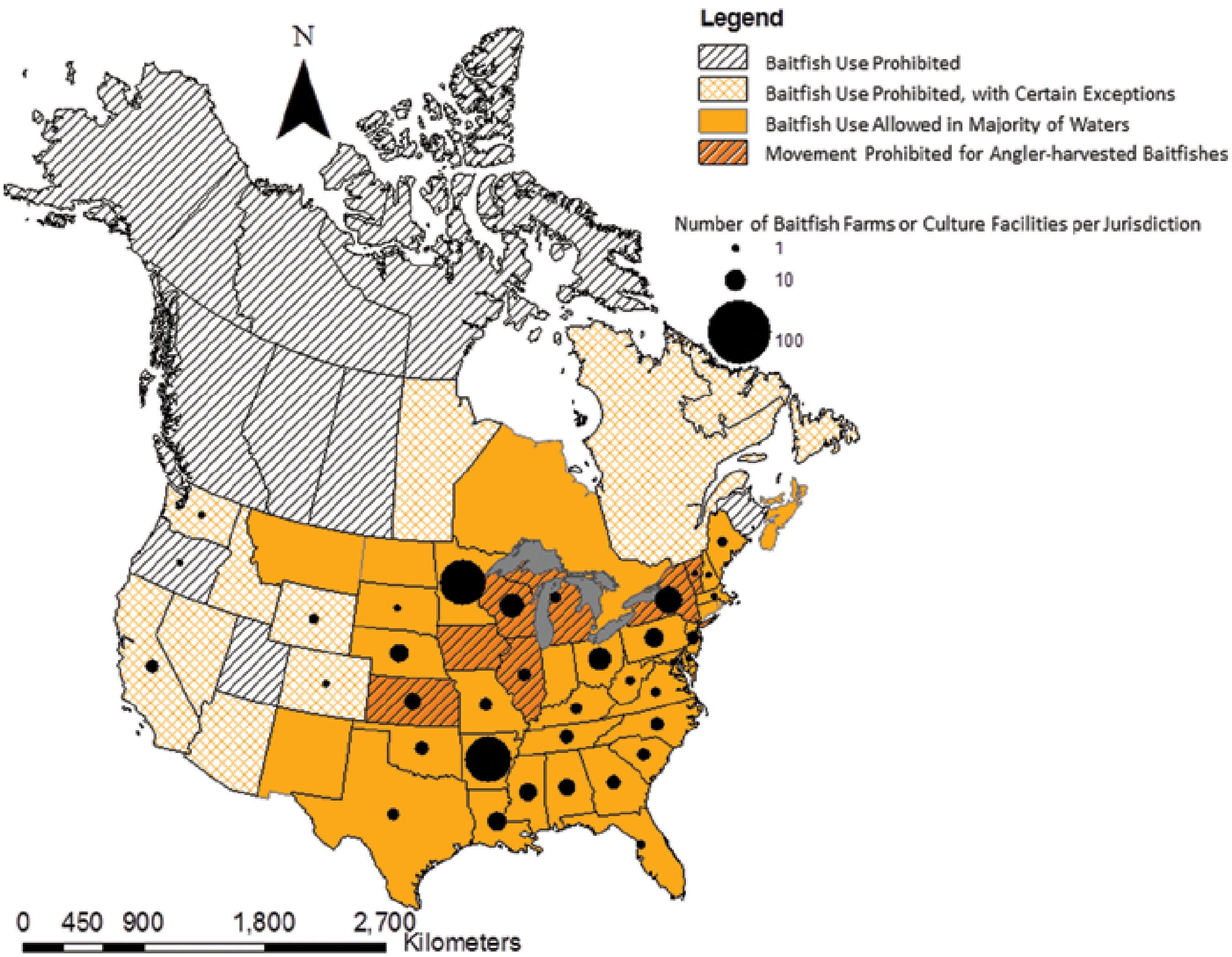


Figure 1. Characteristics of baitfish activity in North America, modified from a recent jurisdictional review (Dunford 2012).

a source of employment and revenue, and their live end-product provides an effective means of capturing game fishes with recreational methods. For many anglers across North America, live baitfish represent a relatively inexpensive source of bait, especially for individuals trapping their own fishes from the wild. Live baitfish are valued by anglers primarily because a live, natural bait provides scent, shape, size, vibration, and visual aspects familiar to game species. These attributes may increase angling effectiveness in a variety of recreational fishing scenarios, such as in turbid water, winter angling, or where inactive fishing techniques may be preferred, especially by new or occasional anglers.

Despite the many positive factors associated with the use of live baitfish for angling, concern exists surrounding the potential for biotic transfer between aquatic ecosystems due to baitfish use. Baitfish capture from the wild, and subsequent transport and release by anglers, may provide an effective pathway for the movement of fishes and their pathogens beyond biogeographic barriers (Litvak and Mandrak 1993; Ludwig and Leitch 1996; Goodwin et al. 2004; Figure 2), with ecological consequences dependent on the characteristics of transported species and recipient water bodies. Concerns surrounding the movement of fishes via baitfish pathways are consistent with a general increased awareness of human-mediated species introductions and their physical vectors (e.g., recreational boats: Rothlisberger et al. 2010; aquaria purchases: Strecker et al. 2011; commercial ships: Frazier et al. 2013) and the vulnerability of aquatic ecosystems to species invasions (Lodge et al. 1998; Sala et al. 2000).

Like many commercial and recreational fisheries, core issues within baitfish fisheries relate to the degree of selection (i.e., capturing target stocks while avoiding nontarget stocks); however, unlike most fisheries, bycatch issues are twofold. Typical bycatch issues, such as incidental capture leading to harm or mortality to nontarget stocks, are pertinent, but additional concerns about the live transfer of bycatch through each stage in the pathway (following inadequate sorting or culling by harvesters, retailers, and anglers; Figures 2A–2C) and movement and release by the angler (Figures 2D and 2E) complete the transfer of fishes from donor to recipient ecosystem. As with many commercial and recreational fisheries, selecting for target stocks is imperfect. Despite harvest practices oriented toward target species, wild harvest may inadvertently capture one or more nontarget species as bycatch, given the propensity for mixed

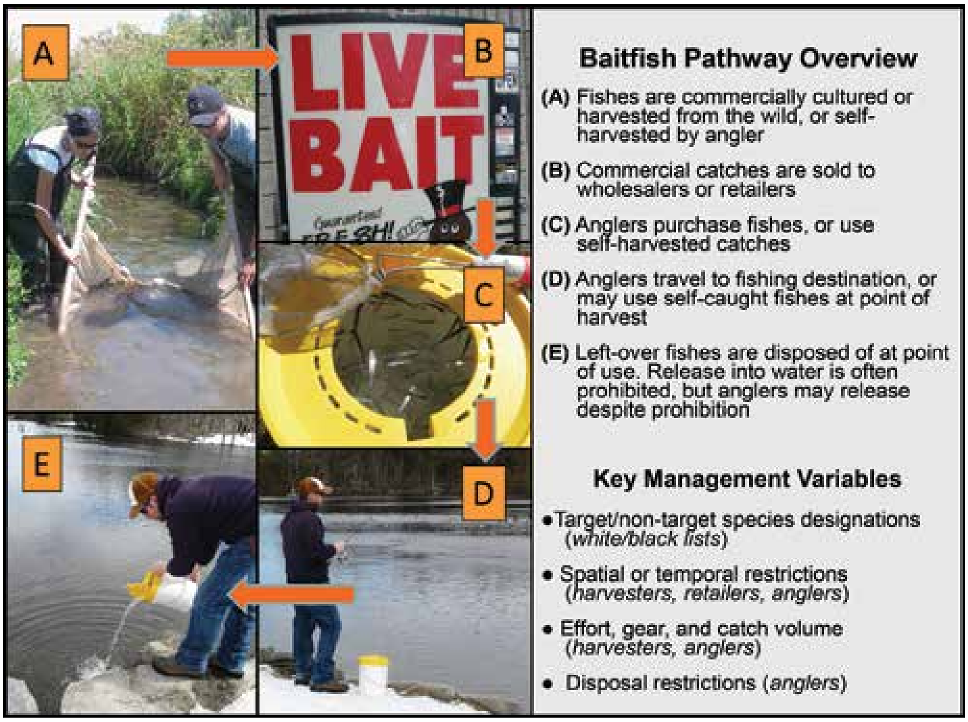


Figure 2. Diagram of baitfish pathways, which vary according to climate, biological resources, and local management.

stocks within harvest ecosystems (Drake and Mandrak 2014b) and difficulty of culling bycatch due to live, small-bodied, abundant target catches that obscure detection of nontarget species, which may also be small in size. Challenging species-level identification for many target and nontarget species, such as juvenile game species, contributes further to the difficulty of culling. Although physical species sorting will occur during and following harvest, undetected nontarget species may be inadvertently sold to baitfish retailers who, despite continued sorting, may inadvertently sell to anglers. Following purchase or self-harvest, nontarget species may remain undetected by anglers, who may transport species to the angling destination. Many jurisdictions prohibit angler release of leftover baitfish, but despite regulation, anglers may release their unwanted or leftover baitfish following travel to the destination waterbody, which may or may not contain the captive target or nontarget species. Release completes the pathway, with the transfer of fishes from donor to recipient ecosystems.

Current understanding of baitfish activity within North America is limited, especially as it relates to the potential for species bycatch and subsequent movement and release of captive species to the wild. This reduces capacity for science-based management decisions concerning the ecological risk of introducing key nontarget species. Recent research regarding the ecological impact of baitfish pathways has established baseline information about key species, their ecological characteristics and pathogens, and invasion potential within the pathway at broad scales (Goodwin et al. 2004; Kilian et al. 2012). To determine the risk of species introductions and guide pathway management toward reducing this risk, we summarize results of an assessment of the Ontario baitfish pathway, from points of commercial harvest and retail operations, through angler use and release, to estimate the incidence of bycatch and introduction of fishes beyond their current geographic range.

Model System—The Ontario Baitfish Pathway

The Ontario baitfish pathway involves a large network of harvesters, retailers, anglers, and destination water bodies (Table 1), providing a suitable system to study the degree of selective fishing and angler activities leading to the transport and introduction of fishes. Ontario's northern climate effectively precludes culturing, so the pathway relies upon wild harvest by commercial operators and self-harvest by anglers. Target species are small-bodied fishes from Catostomidae, Cottidae, Cyprinidae, Gasterosteidae, Percidae, Percopsidae, Salmonidae,

Table 1 . Summary statistics of the Ontario baitfish pathway and angling activities. Monetary values are given in Canadian dollars. Angler summaries are 2010 statistics (DFO 2012), and industry statistics are from 2005 (OMNR and BAO 2006).

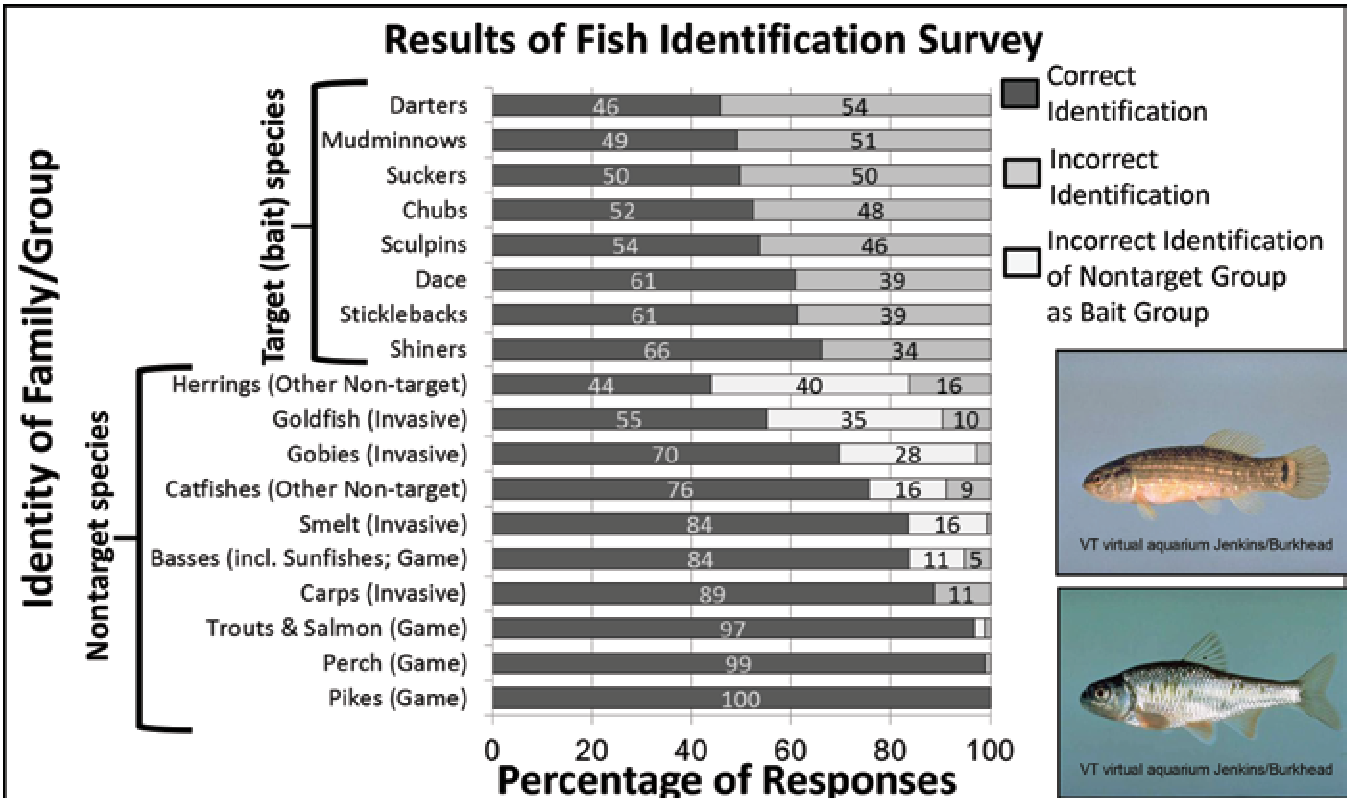
Ontario angler statistics (2010)	
Direct fishing-related expenditures	$912 million
Total resident and nonresident anglers	1.4 million
Total active resident anglers	924,549
Total angling days	16.9 million
Estimated resident angling events involving live baitfish	4.2 million[a]
Ontario baitfish industry (2005)	
Harvesters	670
Dealers/retailers	769
Number of fish harvested	≈100 million
Number of fish sold	≈49 million
Retail value of fish sold	$14 million

[a]Drake and Mandrak (2014a).

and Umbridae families, designated through a provincial white list of allowable species and harvested using live-capture gear (straight and bag seines, minnow traps). Recent estimates of commercial landings in Ontario indicated a yearly harvest of over 100 million fishes sold by several hundred retail dealers to supply substantial resident and nonresident angling activity (1.4 million total resident and nonresident anglers, 16.9 million total angling days, C$912 million in direct fishing-related expenditures; OMNR and BAO 2006; DFO 2012). Angling occurs within a landscape of >225,000 lakes, of which ca. 5% are greater than 1 km^2 in size (Cox 1978). Many of the large, accessible lakes support extensive live bait angling activity (Drake and Mandrak 2010; Hunt et al. 2011), as do numerous rivers throughout the province. Here, we focus primarily on ecological concerns associated with baitfish use through the commercial distribution network, as opposed to self-harvest by the angler. A paucity of data surrounds angler self-harvest, including capture locations, the degree and context of movement following self-harvest, and the extent of species sorting by anglers, especially as to the identification of baitfish and bycatch within personal catches. Preliminary results of a species identification survey collected from anglers who use live baitfish indicates limited identification skill for nongame species, including target baitfish and many nontarget species anticipated to be captured within personal catches as bycatch (Box 1).

Commercial Harvest: Selection of Fishes from Donor Ecosystems

Within Ontario, harvest occurs throughout much of the provincial landscape, including nearshore areas of the Laurentian Great Lakes, their tributaries, and many other inland water bodies (OMNR and BAO 2006). To quantify the potential for bycatch, we modeled baitfish harvest using fishery-independent data and a generic harvest strategy to address the following questions: (1) Which ecosystems exhibit greatest bycatch risk based on spatial cooccurrence between target and nontarget stocks at sites available for harvest? (2) What is the overall probability of capture for any nontarget stock? and (3) What is the relationship between bycatch and harvest effort? We focused on southern, speciose ecosystems (Great Lakes tributaries, hereafter "inland," and nearshore Lake Erie, hereafter "Lake Erie"; see Drake and Mandrak [2014b] for modeling details) due to extensive landings in these regions. To summarize the species contained within harvest ecosystems, we conducted hierarchical cluster analysis of species occurrences using a Jaccard resemblance measure (see Jackson et al. [2010] for details involving unweighted pair-group method with arithmetic averages and approximately unbiased estimates). Many target species cooccur with many nontarget species in the wild, including game, imperiled, and invasive nontarget stocks (Figure 3, harvest



Box 1. Angler fish identification skill is an overlooked component of live bait angling. Anglers incorrectly identifying game, imperiled, invasive, or other nontarget species as bait may unknowingly self-harvest species of concern and transport them beyond their range. Incorrect identification also decreases the ability of anglers to selectively remove nontarget species purchased incidentally as bycatch and may influence risk perception and disposal behavior for captive species. Results show fish identification accuracy based on a survey distributed to anglers who indicated angling with live baitfish (average response *n* = 159). Species were placed in general groups or families (e.g., catfishes) and anglers were required to correctly classify the group. Designations (e.g., game) were assigned based on the greatest number of species in a given category. Suckers were classified as target species given their popularity as bait, despite many nontarget species within the family. Shown are correct classifications (dark grey), incorrect classifications (medium grey), and, for nontarget groups, incorrect identification as groups dominated by bait species (light grey). Photos in the identification test were reproduced with permission from the Royal Ontario Museum, EFISH: The Virtual Aquarium of Virginia Tech, and the Wisconsin Fish Identification Database. Example photos of mudminnows and shiners are displayed.

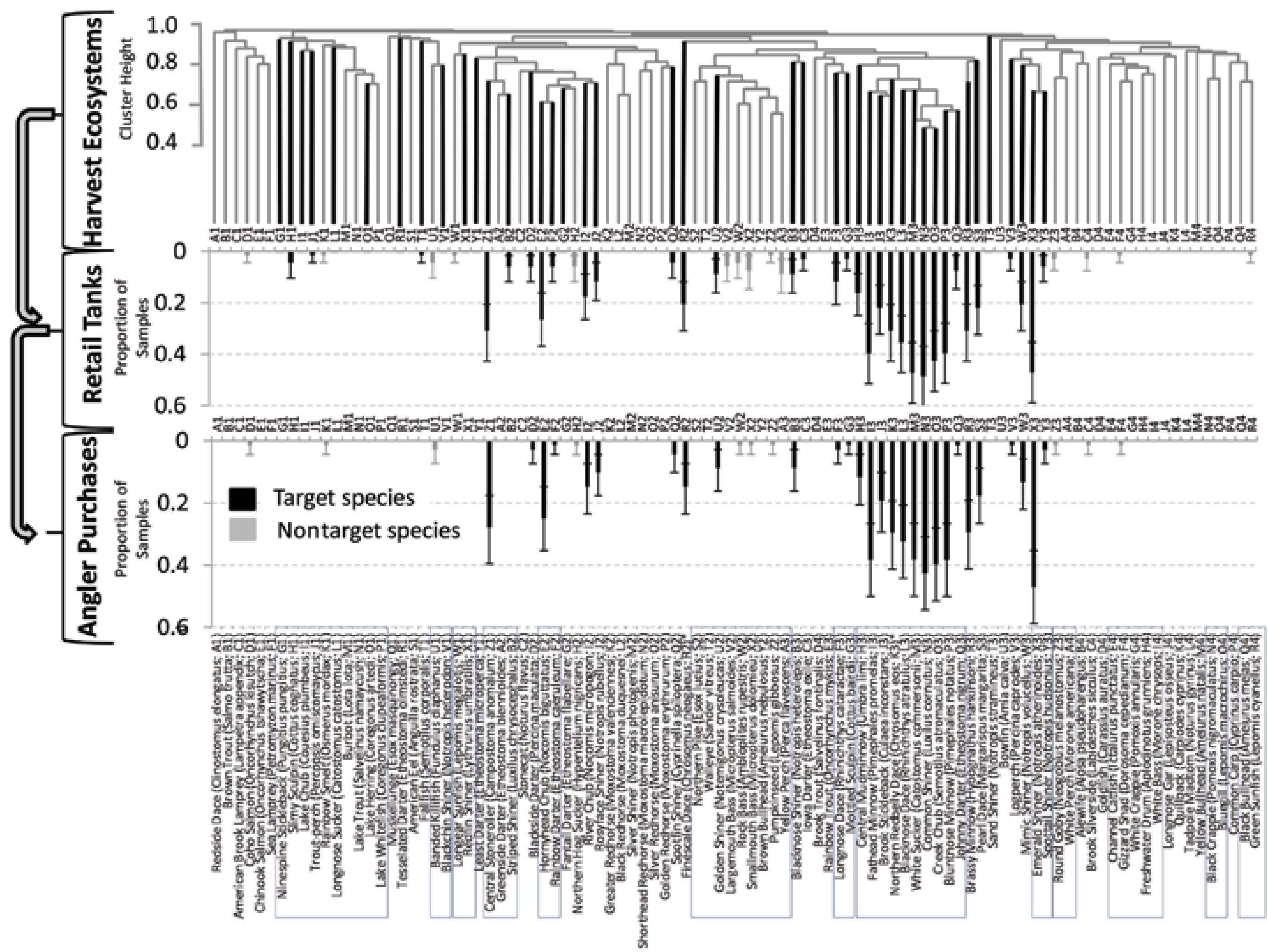


Figure 3. Target (black) and nontarget (grey) species within the Ontario baitfish pathway. The dendrogram within the harvest panel is based on fishery-independent species occurrence data for 6,970 sites accessible for harvest. Species occurring in less than 1% of localities were removed. Rectangles placed over species labels below the x-axis indicate frequently occurring species assemblages (approximately unbiased estimate ≥0.95 following 10,000 iterations). Also shown is the species composition for samples of retail tanks and angler purchases from the Ontario southern region, with y-axis values representing the proportion of samples containing each species and error bars representing the 95% bootstrap confidence limits. Note that River Redhorse, a nontarget species purchased as bycatch, is not included due to its rarity within harvest ecosystems.

ecosystems panel). In some cases, target and nontarget species coexist in frequently occurring assemblages (e.g., Golden Shiner *Notemigonus crysoleucas* with many game species). Based on these stock patterns and a generic harvest model, probabilities of capture for nontarget species associated with a single harvest event ranged from low (median $P_{\text{capture (Four-spine Stickleback | target spp.)}} = 0.000044$; inland harvest) to high (median $P_{\text{capture (Brook Silverside | target spp.)}} = 0.3991$; Lake Erie harvest) but, generally, gamefish stocks held the greatest probability of capture due to their frequent cooccurrence with target species and ease of capture with common gears (Drake and Mandrak 2014b). Many imperiled, invasive, and other nontarget species are also likely to be captured, should a large number of harvest events occur (Drake and Mandrak 2014b). Therefore, the underlying species composition of harvest ecosystems, the capture ability of the gear, and harvest effort are important factors influencing bycatch. The fate of species captured as bycatch varies based on individual harvest and sorting practices. Species captured as bycatch may be discovered and returned to the wild at point of harvest, removed from catches offsite, or remain undetected and inadvertently transferred to the retailer.

Retail Tanks and Angler Purchases: Incidental Transfer Following Harvest

Although the fate of bycatch captured by harvesters is uncertain (i.e., species may be returned to the wild if discovered in the net), the occurrence of nontarget species within retail tanks and angler purchases confirms imperfect culling and sorting practices following harvest from the wild. To assess the degree of selection following commercial harvest and quantify bycatch availability to the angler, we surveyed retail shops to determine the species composition of holding tanks and angler purchases of bait. Only southern facilities (i.e., those contained within the Ontario Ministry of Natural Resources southern region) were sampled due to the species-rich environments in southern Ontario that would provide the greatest potential estimate of bycatch in tanks and purchases. Fishes sold in this region originate primarily from the Lake Erie and inland harvests, providing a comparison of the identity and prevalence of harvested target and nontarget fishes with those sold by retailers. Of the total 181 southern retailers, 50 retailers were selected at random for sampling across two sample periods (August–October 2007, February 2008) to account for seasonality of species composition (i.e., inland fishes sold primarily during the summer, Emerald Shiner [*Notropis atherinoides*] sold primarily during fall, winter, and spring). Due to seasonal retail operations and variable baitfish supply, a total of 68 purchases occurred because some retailers were sampled only once. Purchasing occurred by requesting the legal maximum amount of baitfish allowed per angler from each retailer (120 baitfish in Ontario; see Drake and Mandrak [2014a] for sampling protocol). Individuals responsible for baitfish purchases did not identify themselves as researchers so that retailer behavior would not deviate from the norm, as in excessive sorting or counting. Following baitfish purchase, another member of the study team entered the retailer, identified the goals of the project, and asked the retailer whether they would allow sampling of the tank. In the event that a retailer would not allow sampling (frequent reasoning for refusal was related to fish harm), purchased fishes were used as a proxy for fishes contained in retail tanks. When permission was granted, tank sampling (and purchases) occurred from the tank containing the greatest abundance of fishes, which were captured with between 5 and 15 scoops of a small dip net throughout the extent of the tank. Because of the substantial abundance of fishes in most tanks, only species occurrences were documented.

The majority of fishes within retail tanks and angler purchases were target species; however, game, imperiled, invasive, and other nontarget species as bycatch were documented within tanks (15 nontarget species in total; 8 game, 1 imperiled, 2 invasive, 4 other nontarget species) and purchases (11 nontarget species total; 4 game, 1 imperiled, 2 invasive, and 4 other nontarget species; Table 2, Figure 3, retail tank and angler purchase panels). The proportion of angler purchases containing any nontarget species (0.147) experienced a 45% reduction from the proportion of retail tanks containing any nontarget species (0.324), potentially signifying culling by retailers prior to sale (Figure 4). For 7 of the 10 purchases containing nontarget species as bycatch, the purchase of a single nontarget individual occurred, whereas two purchases contained multiple nontarget individuals of different species, and another contained multiple nontarget individuals of the same species (Table 2). Notable species purchased as bycatch were imperiled River Redhorse (*Moxostoma carinatum*), invasive Round Goby (*Neogobius melanostomus*), and invasive Rainbow Smelt (*Osmerus mordax*; Figures 3, 4, Table 2). Only 0.195% of total individual fishes purchased were nontarget species; therefore, bycatch occurs somewhat frequently in angler bait purchases but often as the occurrence of only one or a few nontarget individuals.

Results indicate generally strong directional selection for target stocks. Most nontarget species within tanks and purchases were those predicted to be frequently captured as bycatch due to their prevalence in harvest areas and ease of capture with common fishery gears. However, certain species prevalent within harvest ecosystems were absent within tanks and purchases (e.g., Alewife *Alosa pseudoharengus*, Common Carp *Cyprinus carpio*, White Perch *Morone americana*; Figure 3), indicating the success of culling by harvesters and retailers or that harvesters avoid specific sites or seasons with high bycatch potential. Some species, such as Yellow Perch (*Perca flavescens*) and Largemouth Bass (*Micropterus salmoides*), were found only in tanks but not purchases, potentially indicating preferential culling for visually striking species. Rare captures as bycatch occur, such as River Redhorse and Coho Salmon (*Oncorhynchus kisutch*), presumably due to the high yearly volume of commercial catches (Table 1) where even the rarest species may be expected over a large number of harvest events that span diverse habitats and species assemblages. Harvest methods and culling, though imperfect, generally remove most nontarget species anticipated as bycatch.

Angler Activities

To determine the ecological implications of bycatch sold to the angler, we modeled how bycatch contained in bait purchases may lead to fish introductions in Ontario lakes. Anglers are critical pathway endpoints because they are highly mobile (Post et al. 2008; Drake and Mandrak 2010, 2014a; Hunt and Lester 2011) and represent the last control point before fish are potentially released to recipient ecosystems. We quantified angler activities, such as the purchase of baitfish, angler travel patterns, and the release of fishes contained in bait buckets, based on a large social survey (n = 1,393 respondents; see Drake and Mandrak [2010] for surveying details), and developed models to understand the transport and release of nontarget fishes by anglers.

Survey results indicated a large fraction of anglers choosing to fish with live baitfish ($P = 0.813$). Anglers indicated purchasing, self-harvesting, and releasing their fishes, with prevalence varying across regions (Table 3). Despite a long history of outreach programs and provincial fishery regulations prohibiting bait bucket release, survey responses indicated that a relatively large proportion of anglers ($P = 0.299$) continue to release unwanted or leftover baitfish, including anglers who release their purchased, as opposed to self-harvested, fishes. Drake (unpublished data) investigated the attitudes of anglers who release their bait. Although anglers indicated many possible reasons for bait release, such as the belief that release does not contribute to the spread of invasive fishes, the best predictive model of release behavior involved two joint variables: (1) releasing anglers indicated that bait release into water was convenient; and (2) releasing anglers also indicated that they believed that releasing leftover fishes provided a forage resource for game fish. This convenience and forage rationale existed for 70.5% of releasing anglers. Although warned about the ecological consequences of baitfish release by management agencies, anglers may also subconsciously believe their release behavior to be benign given their poor discriminative ability of invasive fishes

Table 2 . Pooled composition and abundance of fish purchased from bait retail facilities. Species are listed in decreasing order of prevalence per family; all names are according to Page et al. (2013). Target and nontarget designations refer to species legal or illegal for use as baitfish within Ontario based on Drake and Mandrak (2014b). To highlight the abundance and identity of nontarget species in an individual purchase, letters in brackets indicate each of the 10 purchases (A through J) in which nontarget species were purchased. For example, one of the purchases containing nontarget fish (A) was composed of two Rock Bass and one Smallmouth Bass. Another single purchase (B) contained a single Pumpkinseed, and a third purchase (C) contained a single Coho Salmon. On one occasion, a single purchase (D) contained four of the same nontarget species, and purchases (H) and (I) were both composed of single individuals of Banded Killifish.[a]

Target fishes	Total abundance
Family Cyprinidae	
Emerald Shiner (*Notropis atherinoides*)	10,333
Northern Redbelly Dace (*Chrosomus eos*)	1,055
Common Shiner (*Luxilus cornutus*)	1,002
Fathead Minnow (*Pimephales promelas*)	739
Blacknose Dace (*Rhinichthys atratulus*)	653
Creek Chub (*Semotilus atromaculatus*)	582
Bluntnose Minnow (*Pimephales notatus*)	477
Hornyhead Chub (*Nocomis biguttatus*)	227
Pearl Dace (*Margariscus margarita*)	196
Finescale Dace (*Chrosomus neogaeus*)	193
Mimic Shiner (*Notropis volucellus*)	133
Brassy Minnow (*Hybognathus hankinsoni*)	107
Golden Shiner (*Notemigonus crysoleucas*)	107
River Chub (*Nocomis micropogon*)	98
Central Stoneroller (*Campostoma anomalum*)	76
Spotfin Shiner (*Cyprinella spiloptera*)	47
Rosyface Shiner (*Notropis rubellus*)	41
Blacknose Shiner (*Notropis heterolepis*)	22
Spottail Shiner (*Notropis hudsonius*)	16
Longnose Dace (*Rhinichthys cataractae*)	2
Family Percidae	
Johnny Darter (*Etheostoma nigrum*)	8
Blackside Darter (*Percina maculata*)	3
Rainbow Darter (*Etheostoma caeruleum*)	1
Logperch (*Percina caprodes*)	1
Family Catostomidae	
White Sucker (*Catostomus commersonii*)	376
Family Gasterosteidae	
Brook Stickleback (*Culaea inconstans*)	338
Family Umbridae	
Central Mudminnow (*Umbra limi*)	19
Family Cottidae	
Mottled Sculpin (*Cottus bairdii*)	1

Nontarget Fishes	Total abundance
Game fishes	
Family Centrarchidae	
Rock Bass (*Ambloplites rupestris*)	2 (A)
Smallmouth Bass (*Micropterus dolomieu*)	1 (A)
Pumpkinseed (*Lepomis gibbosus*)	1 (B)
Family Salmonidae	
Coho Salmon (*Oncorhynchus kisutch*)	1 (C)
Invasive fishes	
Family Osmeridae	
Rainbow Smelt (*Osmerus mordax*)	4 (D)
Family Gobiidae	
Round Goby (*Neogobius melanostomus*)	1 (E)
Imperiled fishes	
Family Catostomidae	
River Redhorse (*Moxostoma carinatum*)	1 (F)
Other fishes	
Family Catostomidae	
Northern Hog Sucker (*Hypentelium nigricans*)[a]	18 (G)
Family Clupeidae	
Gizzard Shad (*Dorosoma cepedianum*)	1 (D)
Family Fundulidae	
Banded Killifish (*Fundulus diaphanus*)	2 (H [1], I[1])
Family Atherinidae	
Brook Silverside (*Labidesthes sicculus*)	1 (J)
Total fish purchased	16,886

[a] Since retail sampling, four species (Shorthead Redhorse, Silver Redhorse, Northern Hog Sucker, and Threespine Stickleback) have been listed as target species within the Ontario Fishing Regulations Summary (OMNR 2012). Note that Northern Hog Sucker were not listed as target species during initial sampling (August–September 2007) but were subsequently listed as target species. Northern Hog Sucker are included here as nontarget species, given that they were purchased during initial sampling.

(Box 1) or because angler opinions about the ecological consequences of fish invasions vary strongly (Drake and Mandrak 2014c).

To understand the ecological implications of bycatch in retail purchases, we modeled introduction risk of Round Goby, a key nontarget species given its invasion history in the Laurentian Great Lakes and impending inland range expansion associated with several vectors (e.g., canals, bait) and natural dispersal (Kerr et al. 2005; Mandrak and Cudmore 2010; Poos et al. 2010; see Drake and Mandrak [2014a] for model details). Models estimated 4.2 million yearly angling trips involving live baitfish that exhibited considerable spatial extent throughout the province, with angler effort positively correlated with lake size and sportfish richness (Drake and Mandrak 2010, 2014a). Based on our trip scenario of interest involving the purchase and release of Round Goby by anglers to lakes currently lacking the species, models indicated that most angling trips are benign. Most anglers and trips fail to introduce bycatch, due to the rarity of an angling trip occurring successively with the purchase (as opposed to self-harvest) of bait, the purchase of Round Goby as bycatch within target catches (as opposed to clean target catches), travel to an uninvaded (as opposed to invaded) lake, and release of captive nontarget species (benign trips, median $P = 0.99913$; Drake and Mandrak 2014a). Should the purchase of Round Goby as bycatch occur, most anglers fail to release

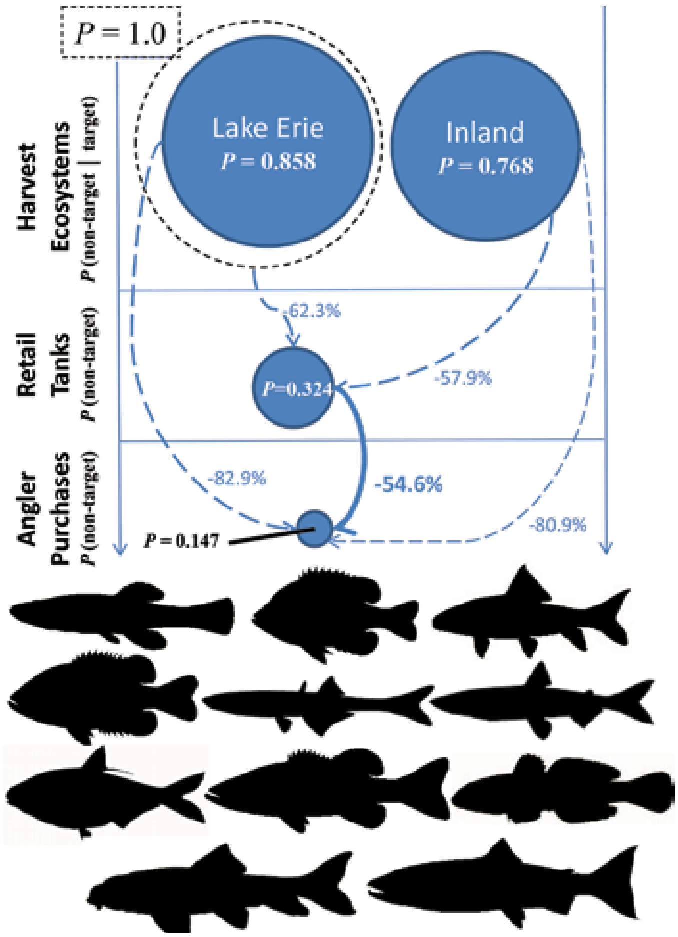


Figure 4. Proportion of harvest ecosystems, retail tanks, and angler purchases containing nontarget species following sampling within Ontario's baitfish pathway. Circles are scaled in size relative to 1.0 (dashed circle) and represent, from top left, the proportion of Lake Erie and Great Lakes tributary harvest sites containing nontarget species, given that they contain target species (i.e., $P_{nontarget \mid target}$); the proportion of retail tanks (middle) and angler purchases (bottom) containing nontarget species ($P_{nontarget}$). The solid arrow represents the reduction of nontarget species from retail tanks to angler purchases; dashed arrows indicate reductions from harvest ecosystems to tanks and purchases, albeit with uncertainty of the specific contribution of Lake Erie vs. inland sites toward the composition of nontarget species in tanks. Species outlines at the bottom are the 11 species purchased as bycatch: (top) Banded Killifish, Pumpkinseed, River Redhorse; (upper middle) Rock Bass, Brook Silverside, Rainbow Smelt; (lower middle) Gizzard Shad, Smallmouth Bass, Round Goby; (bottom) Northern Hog Sucker, Coho Salmon.

their captive species or, if they release, do so to lakes already containing the species, such as the Great Lakes. Substantially fewer trips are risky by successively purchasing Round Goby, traveling to an uninvaded lake, and releasing fishes; median P = 0.00088, or approximately 1 in 1,136 trips). Nonetheless, despite the low probability that an individual trip will lead to species introductions, the substantial yearly volume of angling activity will most likely result in 3,715 Round Goby introduced/year among 1,288 lakes currently lacking the species based on a baseline scenario (Drake and Mandrak 2014a). Similar mechanisms of introduction exist due to the high yearly volume of live bait trips for other species purchased as incidentally as bycatch, such as Smallmouth Bass (*Micropterus dolomieu*), Rock Bass (*Ambloplites rupestris*), and Rainbow Smelt, with each species exhibiting a high probability of being introduced during greater

Table 3 . Proportion of anglers indicating participation in certain behaviors within a given year, based on results of a social survey of anglers across Ontario (overall) and for each of Southwestern Ontario (SW, postal district N), the Greater Toronto Area (GTA, postal district L), Metropolitan Toronto (M, postal district M), Eastern Ontario (E, postal district K), and Northern Ontario (N, postal district P). The term "transport" refers to anglers indicating that they fish with self-harvested baitfish in waters other than where they were captured.

Behavior	Proportion of participating anglers (overall and per region)					
	Overall	SW	GTA	M	E	N
(A) Purchase but not self-harvest, given fish with live baitfish	0.813	0.792	0.804	0.774	0.749	0.922
(B) Purchase but not self-harvest, given fish with live baitfish	0.467	0.419	0.533	0.596	0.426	0.386
(C) Self-harvest but not purchase, given fish with live baitfish	0.021	0.023	0.022	0.000	0.017	0.028
(D) Self-harvest and purchase, given fish with live baitfish	0.511	0.558	0.444	0.404	0.557	0.586
(E) Release given purchase or self-harvest	0.299	0.359	0.324	0.326	0.261	0.225
(F) Release and transport given self-harvest	0.095	0.079	0.107	0.056	0.069	0.118

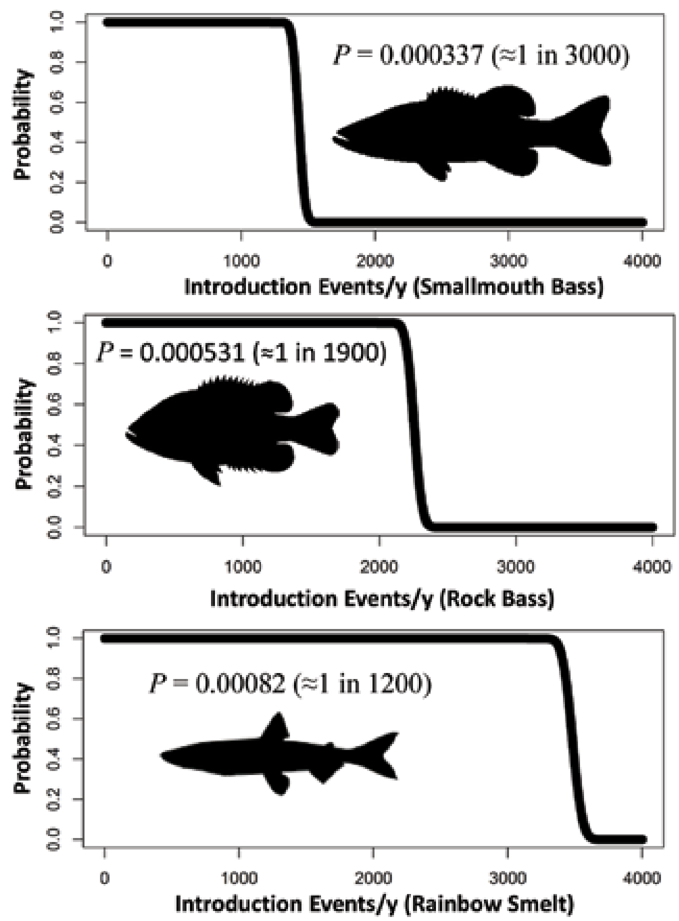


Figure 5. Probability (y-axis) of introducing Smallmouth Bass, Rock Bass, and Rainbow Smelt during at least *n* events/year (x-axis) to lakes currently lacking the species. Plots were derived as 1 − average cumulative probability density using the baseline Poisson agent-based model described in Drake and Mandrak (2014a). Probability values in inset represent the joint per trip probability of releasing purchased bycatch to a lake lacking the species.

than 1,000 events/y under the same baseline scenario (Figure 5; results obtained using model from Drake and Mandrak 2014a). Therefore, although species-specific bycatch rates in the Ontario live bait pathway are relatively low, and specific angling trips with the potential to release nontarget species are infrequent, the sheer volume of pathway activity (harvest events and live bait trips) strongly increases the probability that species are introduced beyond their native range within a given year (Drake and Mandrak 2014a). Nonnegligible species introduction risk exists, with a substantial number of fish introductions attributed to bycatch, fishing volume, and the many variations in live bait angler behavior (see Ludwig and Leitch [1996] for similar mechanisms and Box 2 for an assessment of bycatch introduction risk following self-harvest by anglers).

Species introductions are most likely at lakes exhibiting multiple risk factors: large physical size, diverse sportfish populations, and physical proximity to large angling populations and source populations of nontarget fishes, though most lakes are not immune to receiving bycatch given the many permutations of trip activity (Drake and Mandrak 2014a). Although the survival, establishment, and ecological impact of nontarget fishes following their introduction is extremely uncertain, many of the highest-risk lakes received a sufficient number of individuals each year to surpass demographic barriers to establishment for prominent fish invaders, such as the Round Goby (Vélez-Espino et al. 2010). Our models indicate that despite relatively low bycatch rates, the suite of nontarget species purchased incidentally will be introduced across the provincial landscape (Figure 5), as will those species documented in the future as bycatch within tanks and purchases.

Opportunities for Bycatch Reduction: Risk Management in the Face of Wild Harvest

Given our models and the incidence of nontarget fishes in retail tanks and angler purchases, what conclusions can be drawn about reducing bycatch and thus the ecological risk of species introductions attributed to the baitfish pathway? Logically, reducing bycatch during harvest from the wild will decrease the incidence of nontarget fishes throughout the commercial supply chain. This, in turn, will reduce the magnitude of species introductions following transport and release by anglers; however, bycatch reduction is no small task due to diverse species assemblages in many harvest ecosystems, gear effective at capturing many small fishes, challenging species identification, and scale of the fishery. To reduce the risks associated with the live transfer of bycatch, Ontario, as with many Midwestern states, has implemented the Aquatic Invasive Species-Hazard Analysis and Critical Control Point training program (Gunderson and Kinnunen 2001), which educates commercial harvesters about the risks of invasive fishes and pathogens and the need for effective species sorting. Despite the implementation of this program in Ontario during 2008, the incidence of nontarget fishes in purchased bait appears to have remained relatively constant (Drake, unpublished data), indicating either that (1) harvester training is ineffective and has no influence on bycatch rates; (2) due to its infancy, the program has yet to achieve its goals; or (3) irrespective of harvester training, existing bycatch rates are as low as possible within the current management regime. In other words, given the scale of the fishery and despite the best intentions of harvesters and the Aquatic Invasive Species-Hazard Analysis and Critical Control Point training program, a relatively low level of bycatch may be inevitable due to the nature of high-volume live-capture fisheries involving wild stocks. Harvesters and retailers are culling most nontarget species from catches, and despite these notable successes, low bycatch rates lead to species introductions with likely ecological consequences due to the sizable number of harvest and angling events each year.

If bycatch rates are currently as low as possible, achieving further bycatch reduction will require pathway management shifts beyond harvester training, such as overall reductions in harvest effort, which will reduce the probability of capture for widely distributed stocks like Yellow Perch, Rock Bass, or Smallmouth Bass or spatial harvest restrictions to address localized species of concern, such as Round Goby (Drake and Mandrak 2014b). Other harvest management initiatives, such as reexamination of allowable target species or temporal restrictions to reduce the probability of encountering congregations of nontarget fishes, may provide further opportunity to reduce risks. However, management shifts toward reducing bycatch will inevitably decrease the overall efficiency of harvest, so, like many fisheries, competing objectives exist. Alternatively, bycatch training programs targeting retailers as critical endpoints may provide important opportunities for removing bycatch within commercial supplies. Retailer programs should focus on enhancing the identification skill of retailers for target vs. nontarget species, in conjunction with installing designated receptacles at retail facilities for the placement of nontarget species following their discovery. Such an initiative acknowledges the incidence of bycatch within the fishery and may promote a proactive approach to species culling by retailers.

Despite the practical difficulties of implementing strategies to reduce risks, effectively reducing bycatch and the release by anglers will strongly influence the number of fish introduced each year (Drake and Mandrak 2014a). For example, the most likely number of Round Goby introduced would be zero following a 90% reduction of purchased bycatch, because the very low number of Round Goby sold either would not be released or would be released to popular angling lakes already containing the species, such as lakes Erie, Ontario, and Simcoe (Drake and Mandrak 2014a). Thus, risk-based bycatch thresholds exist. Targeting angler perceptions involving the convenience of bait release, such as with designated trash receptacles for leftover baitfish at high-risk lakes, will also reduce the number of nontarget fishes introduced. However, as with bycatch, some low-level of risky activity may persist with a subset of anglers continuing to release despite targeted management. Therefore, effective ecological risk reduction within Ontario's baitfish pathway is probably multifaceted by targeting both bycatch within the commercial supply chain and human dimensions relevant to risky angler behavior.

Box 2. Self-harvest of baitfish and bycatch by anglers

Self-harvest of fishes by anglers is an important component of live bait angling. As with commercial harvest, bycatch may occur during self-harvest. Anglers inadvertently transporting and releasing nontarget fishes beyond point of capture are an effective mechanism for the overland transport of a variety of small fishes. Using the binomial probability formula following Ludwig and Leitch (1996), P (K successes in N trials) = $\binom{n}{k} p^k(1-p)^{n-k}$, we present an estimate of the probability (P) that at least 100, 1,000, or 10,000 events/year will involve the transport and release of bycatch self-harvested by anglers, given p, the estimated per trip probability of bycatch, transport, and release; k, the number of successes (transport and release of bycatch/year); and n, the overall number of trials (angling events involving self-harvest; average 1,183,332 trips/year; Drake and Mandrak 2014c). Although the identity and prevalence of bycatch within self-harvested catches is unknown, most gear used by anglers (minnow traps, seines) capture a variety of target and nontarget fishes alike, and poor identification skill (Box 1) may influence culling decisions and effectiveness. Given the volume of trips involving self-harvest, even low per trip probabilities of contamination with nontarget fishes can lead to a high probability of at least 100 or 1,000 events/year in which nontarget fishes are released to where they were not harvested.

Hypothetical probability of contamination of self-harvested catches with nontarget fishes X	Per-trip probability of transport ∩ release | self-harvest* =	Per-trip probability (p) of bycatch ∩ transport ∩ release | self-harvest	Cumulative probability (P) that at least k events/year will involve the transport and release of bycatch self-harvested by anglers		
			100 events/year (k)	1000 events/year (k)	10000 events/year (k)
P = 0.001 (≈1 in 1000)	P = 0.095	P = 0.000095	P = 0.8704947	P = 0.0	P = 0.0
P = 0.002 (≈1 in 500)	P = 0.095	P = 0.00019	P = 1.0	P = 0.0	P = 0.0
P = 0.01 (≈1 in 100)	P = 0.095	P = 0.00095	P = 1.0	P = 0.9999137	P = 0.0
P = 0.025 (≈1 in 40)	P = 0.095	P = 0.002375	P = 1.0	P = 1.0	P = 0.0
P = 0.05 (≈1 in 20)	P = 0.095	P = 0.00475	P = 1.0	P = 1.0	P = 0.0
P = 0.1 (≈1 in 10)	P = 0.095	P = 0.0095	P = 1.0	P = 1.0	P = 1.0

*maximum estimate from Table 3 (behavior may occur for some, but not all, of self-harvested trips); we also assume that bycatch is not culled from catches when transport and release occurs
Photo credit: Fisheries and Oceans Canada.

IMPLICATIONS FOR MANAGEMENT: BAITFISH ACTIVITY ACROSS NORTH AMERICA

As with all recreational and commercial fisheries, management of baitfish across North America must focus on relevant ecological, social, and economic factors. We present an assessment of certain ecological factors and, like many before us (Litvak and Mandrak 1993; Ludwig and Leitch 1996; Lodge et al. 2000; Kerr et al. 2005; Keller et al. 2007; DiStefano et al. 2009; Kilian et al. 2012), draw attention to the potential for human-mediated species transport beyond biogeographic barriers. Ultimately, the ecological risk posed by bait pathways across North America is dependent on the nature of baitfish supply (e.g., wild harvest vs. culture), scale of associated commercial and recreational fisheries, and context of fish movement, with many scenarios of baitfish supply and angler use possible due to the complexity of jurisdictional regulations. In some jurisdictions, species-specific baitfish white lists and clear regulations pertaining to harvest and angling with live baitfish are sorely needed.

Fishery managers reviewing potential risks should focus on the potential for species bycatch and movement of fishes as key joint variables. For example, in jurisdictions such as Michigan, New York, and Wisconsin, regulations dictate that fishes self-harvested by the angler must be used at point of harvest (Dunford 2012). Though bycatch may occur during self-harvest, these regulations eliminate the overland movement of fishes (as one of the key joint variables), thus preventing biotic transfer for law-abiding anglers. In this context, the ecological consequences of angler bait release are also minimized. However, this approach limits the availability of angler-caught bait during ice-cover seasons, so supplementation with commercial catches is often warranted, with enforcement of personal vs. commercial fishes through a purchase receipt system. Alternatively, for many southern states (e.g., Kentucky, West Virginia), baitfish supply is supplemented through culture of common species such as Fathead Minnow (*Pimephales promelas*) and Golden Shiner. Culture strongly reduces potential for bycatch as the second key variable. However, as with pathways involving wild harvest, the volume and extent of the overland distribution network associated with many baitfish farms dictates that contamination with nontarget fishes or pathogens pose strong potential for rapid overland spread, should unwanted species fail to be discovered and contained (Goodwin et al. 2004). Pathogen and fish health certification programs undertaken by bait farmers, such as the Arkansas Certified Baitfish program (www.safebaitfish.org), are a positive step to reduce the likelihood of such events.

Where wild harvest exists, our results emphasize that bycatch can occur with important ecological implications, even within well-managed commercial supplies. Realistic opportunities for risk reduction exist, such as harvest management, bycatch control points at retailers, and outreach programs focusing on perceptions about bait release, though most risk management strategies cannot eliminate risk due to the scale of fisheries and stochasticity of relevant ecological and social processes. Therefore, determining the allowable spatial scale of fish movement between donor and recipient ecosystems, itself a risk tolerance decision, is warranted in the event that fishes and pathogens are transported and introduced despite risk reduction programs. Management agencies may pursue chain-of-custody systems for the commercial supply chain and anglers, so that the origin of baitfish can be determined readily during enforcement or in the event of discovery of an undesirable species or pathogen within a harvested watershed or culture facility.

Our assessment of the Ontario fishery identifies certain successes, and many challenges, for the current and future management of baitfish pathways. We provide only a sample of risk reduction measures that should be adopted to ensure the future integrity of these social–ecological systems. Given that most bait industries have economic and ecological values similar to other capture fisheries, we encourage managers to approach bait issues with the same tools used for commercial and recreational fisheries, such as species, effort, gear, and spatiotemporal regulations, to ensure continued productivity of bait fisheries in North America.

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REFERENCES

Cox, E. T. 1978. Counts and measurements of Ontario lakes. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

DFO (Department of Fisheries and Oceans Canada). 2012. Survey of recreational fishing in Canada, 2010. Fisheries and Oceans Canada, Ottawa, Ontario.

DiStefano, R. J., M. E. Litvan, and P. T. Horner. 2009. The bait industry as a potential vector for alien crayfish introductions: problem recognition by fisheries agencies and a Missouri evaluation. Fisheries 34:586–597.

Drake, D. A. R., and N. E. Mandrak. 2010. Least-cost transportation networks predict spatial interaction of invasion vectors. Ecological Applications 20:2286–2299.

———. 2014a. Bycatch, bait, anglers, and roads: quantifying vector activity and species introduction risk across lake ecosystems. Ecological Applications 24:877–894.

———. 2014b. Harvest models and stock co-occurrence: probabilistic methods for estimating bycatch. Fish and Fisheries 15:23–42. doi/10.1111/faf.12005/abstract

———. 2014c. How will invasive species impact the future of fisheries? *In* W. W. Taylor, A. J. Lynch, and N. Leonard, editors. Future of Fisheries: Perspectives for Emerging Professionals. American Fisheries Society, Bethesda, Maryland.

Dunford, L. A. 2012. 2012 Survey of North American recreational baitfish regulations. Fisheries Policy Section, Biodiversity Branch, Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada.

Frazier, M., A. W. Miller, and G. M. Ruiz. 2013. Linking science and policy to prevent the spread of invasive species from the ballast water discharge of ships. Ecological Applications 23:287–289.

Goodwin, A. E., J. E. Peterson, T. R. Meyers, and D. J. Money. 2004. Transmission of exotic fish viruses. Fisheries 29(5):19–23.

Gunderson, J. L., and R. E. Kinnunen, editors. 2001. Aquatic invasive species—hazard analysis and critical control point training curriculum, 2nd edition. University of Minnesota, Duluth.

Hunt, L. M., R. Arlinghaus, N. Lester, and R. Kushneriuk. 2011. The effects of regional angling effort, angler behaviour, and harvesting efficiency on landscape patterns of overfishing. Ecological Applications 21:2555–2575.

Hunt, L. M., and N. P. Lester. 2011. The effect of forestry roads on access to remote fishing lakes in northern Ontario, Canada. North American Journal of Fisheries Management 29:586–597.

Jackson, D. A., S. C. Walker, and M. S. Poos. 2010. Cluster analysis of fish community data: "new" tools for determining meaningful groupings of sites and species assemblages. Pages 503–527 *in* K. Gido and D. A. Jackson, editors. Community ecology of stream fishes: concepts, approaches, and techniques. American Fisheries Society, Bethesda, Maryland.

Keller, R. P., A. N. Cox, C. Van Loon, D. M. Lodge, L.-M. Herborg, and J. Rothlisberger. 2007. From bait shops to the forest floor: earthworm use and disposal by anglers. American Midland Naturalist 158:321–328.

Kerr, S. J., C. S. Brousseau, and M. Muschett. 2005. Invasive aquatic species in Ontario: a review and analysis of potential pathways for introduction. Fisheries 30(7):21–20.

Kilian, J. V., R. J. Klauda, S. Widman, M. Kashiwagi, R. Bourquin, S. Weglein, and J. Schuster. 2012. An assessment of a bait industry and angler behavior as a vector of invasive species. Biological Invasions 14:1469–1481.

Litvak, M. K., and N. E. Mandrak. 1993. Ecology of freshwater baitfish use in Canada and the United States. Fisheries 18(12):6–13.

Lodge, D. M., R. A. Stein, K. M. Brown, A. P. Covich, C. Brönmark, J. E. Garvey, and S. P. Klosiewski. 1998. Predicting impact of freshwater exotic species on native biodiversity: challenges in spatial scaling. Australian Journal of Ecology 23:53–67.

Lodge, D. M., C. A. Taylor, D. M. Holdich, and J. Skurdal. 2000. Reducing impacts of aquatic crayfish introductions: new policies needed. Fisheries 25(8):21–23.

Ludwig, H. R., Jr., and J. A. Leitch. 1996. Interbasin transfer of aquatic biota via anglers bait buckets. Fisheries 21(7):14–18.

Mandrak, N. E., and B. Cudmore. 2010. The fall of native fishes and the rise of non-native fishes in the Great Lakes basin. Aquatic Ecosystem Health and Management 13:255–268.

OMNR (Ontario Ministry of Natural Resources). 2012. Fishing Ontario recreational fishing regulations summary. Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada.

OMNR (Ontario Ministry of Natural Resources) and BAO (Bait Association of Ontario). 2006. The commercial bait industry in Ontario: statistical report, 2005. Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada.

Page, L. M., H. Espinosa-Pérez, L. T. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrak, R. L. Mayden, and J. S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico, 7th edition. American Fisheries Society, Special Publication 34, Bethesda, Maryland.

Poos, M. S., A. J. Dextrase, A. N. Schwalb, and J. Ackerman. 2010. The secondary invasion of the round goby into high diversity Great Lakes tributaries and species at risk hotspots: potential new concerns for endangered freshwater species. Biological Invasions 12:1269–1284.

Post, J. R., L. Perrson, E. A. Parkinson, and T. van Kooten. 2008. Angler numerical response across landscapes and the collapse of freshwater fisheries. Ecological Applications 18:1038–1049.

Rothlisberger, J. D., W. L. Chadderton, J. McNulty, and D. M. Lodge. 2010. Aquatic invasive species transported via trailered boats: what is being moved, who is moving it, and what can be done. Fisheries 35:121–132.

Sala, O., F. S. Chapin III, J. J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L. F. Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. M. Lodge, H. A. Mooney, M. Oesterheld, N. Leroy Poff, M. T. Sykes, B. H. Walker, M. Walker, and D. H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science 287:1770–1774.

Strecker, A. L., P. M. Campbell, and J. D. Olden. 2011. The aquarium trade as an invasion pathway in the Pacific Northwest. Fisheries 36:74–85.

U.S. Department of Agriculture. 2005. 2002 Census of agriculture: census of aquaculture, volume 3. United States Department of Agriculture, Special Studies Part 2, AC-02-SP-2. Beltsville, Maryland.

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011. National survey of fishing, hunting and wildlife-associated recreation.

Vélez-Espino, L. A., M. A. Koops, and S. Balshine. 2010. Invasion dynamics of round goby (*Neogobius melanostomus*) in Hamilton Harbour, Lake Ontario. Biological Invasions 12:3861–3875.

ESSAY

Are Current Research Evaluation Metrics Causing a Tragedy of the Scientific Commons and the Extinction of University-Based Fisheries Programs?

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Most academics and, by the same token, departments and whole organizations, are today explicitly ranked, or implicitly valued, according to quantitative measures of research output, such as number of publications in journals with an impact factor, citation rates, and cumulative grant income. A prominent example is the British Research Assessment Exercise (www.rae.ac.uk). Similarly, all search processes to fill tenure-track research positions will follow, or be influenced by, some metric of research productivity. There are obvious downsides to such procedures (Lawrence 2007; Alberts 2013), yet current practice continues to promote the ranking of people or research units based on ill-defined performance metrics that are often only modestly and sometimes even completely uncorrelated with scientific quality (Brembs et al. 2013; Eyre-Walker and Stoletzki 2013; Macilwain 2013). I contend here that nontrivial social costs are emerging from the perverse focus of many presidents, deans, hiring committees, and researchers on quantity-based output metrics. In fact, I suggest that the orientation of the research community to meet these powerful metrics collectively undermines, slowly but steadily, the scientific and higher education systems (Weingart 2005; Adler and Harzing 2009). These developments bear an analogy to the open-access exploitation of natural resources (Hardin 1998) and financial markets (Ségalat 2010). In both cases, individual rational behavior designed to maximize individual payoff causes system destruction if it remains self-organized and unmanaged. To manage undesirable changes, leaders of the game have to rapidly modify its rules. Otherwise, our science and higher education systems are doomed to produce suboptimal outcomes at best or to become dysfunctional at worst. The consequences for university-based fisheries science might be particularly severe as will be outlined below.

At least four reasons contribute to academia's contemporary "obsession with quantity" (Fischer et al. 2012a), for simplicity defined here as a tendency to focus on the production of long lists of papers in journals with a high impact factor. First, papers are needed to disseminate science and hence more of them supposedly signals a more successful and productive scientist or research group. Second, paper-based productivity promotes one's career by safeguarding tenure and promotion. Third, producing many papers elevates one's visibility, which in turns affects the acquisition of research funds, networks, and reputation. Fourth, papers and the impact factors of journals in which they are published have become extremely important in the evaluation of grant proposals, individuals, groups, departments, and entire organizations. Consequently, most academic administrations have created strong incentives to their academic staff to publish more and "better." Despite recent calls to focus on "influence" rather than quantity (Donaldson and Cooke 2013), better often implies larger numbers of papers printed in journals with a high impact factor—the latter essentially being a metric of the average citation frequency of recent articles published in a given journal. But there is a fundamental issue that has gone unnoticed by many: the impact factor of a journal is useful to rank journals, but it is entirely unsuitable to judge the scientific quality of an individual article or the scientist in charge (e.g., Alberts 2013; Brembs et al. 2013; Eyre-Walker and Stoletzki 2013). Similarly, I am doubtful that the cumulative grant income acquired is a suitable correlate of scientific quality, and the same doubts can be cast toward other popular metrics of research performance such as citation rates.

To be clear: I am not arguing against the need to be productive as a researcher; I am also not against publication in high impact factor journals per se—I certainly understand the role and importance of publications in high-profile (i.e., high impact factor) journals such as *Nature* or *Science*, and I value competition for jobs. What I criticize, however, is the *exclusive focus* on a few highly biased productivity metrics, the associated overproduction of research papers to the detriment of other research output, and the disproportionate importance of a few journals to justify status, tenure, and promotion, all of which are also sources of concern to others (Weingart 2005; Lawrence 2007; Alberts 2013; Macilwain 2013; Schekman 2013). Moreover, some of the now popular research metrics have an infinite scale (e.g., number of papers produced, grant money acquired). Hence, there is in principle no end to the publish-or-perish race, which is problematic for young scholars, who often respond with unhealthy work loads (Schäfer et al. 2011). Individual-level downsides of the obsession with quantity have been identified and encompass disrupted work–life balance, loss of creativity, and reduced time for reflection and exchange (Fischer et al. 2012a, 2012b). Socially, we are beginning to see more downsides, such as the reduced attractiveness of the science profession to female researchers (Lockwood et al. 2013), a tendency to avoid risky and groundbreaking research (Lawrence 2007), reduced scientific integrity (Hayer et al. 2013), and erosion of collegiality when it comes to investing time into supporting others without expecting an immediate payoff through coauthorship (Kaushal and Jeschke 2013). In this essay, I list further social costs associated with the current focus on quantity-based research products. I structure these in four dimensions that I feel are highly relevant to the fisheries profession. The list is by no means complete and reflects my experiences in European countries such as Germany, the United Kingdom, France, and Spain. I will end with a call for action to reverse (Europe) or avoid (United States) the negative trend we are seeing for the science system as well as more specifically for the role of university-based fisheries research.

THE SOCIAL COSTS OF BOGUS RESEARCH PERFORMANCE MEASURES

The first social cost associated with a focus on productivity-based research metrics is the danger of erosion of the quality of scientific publications and of peer review. In fact, due to the pressure to publish in the most prestigious journals, most high-demand journals are swamped with submissions. Many of these submissions include flashy novelty claims matched to rigorous word limits (Schekman 2013). As a result, many papers in highly ranked journals, for the sake of brevity, readability, and clarity, tend to fall short on important methodological information, critical contextual information, and citations. In particular, for the sake of readability, alternative views and results are often "cleaned" away in the preparation of the manuscript to produce a more coherent story that appears more convincing to reviewers. In addition, it seems that the articles that are preferred by the high-profile journals offer the potential to generate news headlines, which are not necessarily the ones of highest scientific quality in a given discipline (for an example in fisheries, see Hilborn 2006). Needless to say, most submissions to highly ranked journals are rejected due to space limitations.

A plethora of new journals—many of which are open access journals of dubious quality (Bohannon 2013)—have appeared on the horizon to absorb the many inevitable rejections. There is a fair chance element in academic publishing (Neff and Olden 2006). Hence, one can now publish anything somewhere, even with questionable quality (Bohannon 2013). One just needs to be persistent enough and resubmit previously rejected papers, usually climbing down the impact factor ladder. For the individual, the strategy will normally pay off, because it is often the total paper count that guarantees survival in the academic system (Haslam and Laham 2010). But there are unaccounted social externalities, because we can no longer guarantee the quality control mechanism of peer review. In fact, as associate editor of several journals, I have realized that it is nowadays increasingly difficult to secure timely reviews of good quality, probably because far too many articles are circulating (and recirculating after initial rejection) in the system—a number that can no longer be absorbed and assessed by the peer-review system. Hence, the backbone of the scientific enterprise is at risk of dilution due to a mixture of loss of scientific integrity (Hayer et al. 2013) and overburdening of the peer-review system.

A second relevant social downside of contemporary publication pressure relates to the erosion of incentives to invest into teaching, mentoring, and education outside one's own lab (Adler and Harzing 2009). In fact, because of the now global market for students and postdocs, a professor (and indeed many research-heavy high-rank universities) are better off free-riding on the educational investments by others and instead invest scarce time into generating grant income, publishing, and polishing marketing products to attract the most talented graduate students. Moreover, the best research professors can today buy out of teaching duties and, in fact, in many hiring processes I have followed, teaching and mentoring quality are of minor importance and sometimes not even assessed by the hiring committee. In addition, "high-impact" researchers often manage to secure reduced teaching loads during hiring negotiations, many of whom are so specialized in their research that they might be neither able nor willing to produce a basic lecture for undergraduates. It is acknowledged that not everybody can and will do both research and teaching with equal quality. Yet, for all researchers, mentoring of a new generation of scientists should be a key endeavor, which will often involve some form of high-quality teaching. Displaying the educational efforts elsewhere to be able to focus strongly on the production of grants and papers undermines von Humboldt's (1986) principle of the unity of research and education, which has potentially far-reaching societal consequences by affecting the future generations who leave our higher education system. In this context, as one reviewer of this manuscript noted, even the most high-ranking and research-intensive universities typically generate most of their funds from teaching. Therefore, the reduction of interest and competency in university-level undergraduate and graduate teaching by selected professors might ultimately also damage the financial stability of its employer.

There is a fundamental issue that has gone unnoticed by many: the impact factor of a journal is useful to rank journals, but it is entirely unsuitable to judge the scientific quality of an individual article or the scientist in charge.

Third, the wider scholarship and societal impact associated with tax-funded research activities is declining as output-oriented researchers rationally reorient their behaviors to the production of papers. Unfortunately, many of the now unattractive other activities of our profession are key to maintaining the functionality of the scientific system and improving our society, such as engaging in outreach, advising fisheries management agencies, or reviewing organizations, programs, grants, and manuscripts. Almost ironically, many tax-funded environmental and ecological scientists in universities whose task is, broadly speaking, to help society overcome fundamental ecological and environmental challenges through knowledge-based innovation and good citizenship seem to engage less and less in activities that safeguard our future. Instead, preoccupation with the number of technical papers produced and the marketing of oneself has become an end in itself, which severely reduces the impact science can have in society.

Finally, "bogus measures of scientific quality" (Macilwain 2013, p. 255), such as the cumulative impact factor acquired by a candidate through publications, disqualify academics who study applied questions related to natural resource use and may lead to their extinction in universities. This is for two main reasons. First, the maximum and the average impact factor of applied journals (e.g., in the field of fisheries, *Canadian Journal of Fisheries and Aquatic Sciences*, *Transactions of the American Fisheries Society*, *Fisheries Management and Ecology*) is usually lower than the maximum and average impact factor of basic molecular, ecological, or evolutionary journals (e.g., *American Naturalist*, *Ecology*, *Ecology Letters*, *Molecular Ecology*; Schäfer et al. 2011). Therefore, even if fisheries researchers publish in, say, the top five fisheries journals, they will not earn the same credit as a basic ecologist or evolutionary biologist publishing identically in their disciplinary outlets. Second, applied scholars are disfavored due to the lower ranking of the source of grant money. Money generated, for example, from an applied source such as fisheries agencies is often seen as inferior compared to money attracted from funding sources that support basic research (e.g., National Science Foundation) because basic funds are perceived as more competitive. As a result, fisheries researchers that do not manage to reach out to more basic journals (compare Jensen et al. 2012) and that do not secure basic research funding will suffer selective disadvantages compared to more basic natural scientists and may consequently not reach a tenure-track position in a prestigious school.

A focus on publications in high-impact-factor journals and on basic funding is particularly problematic where there is no tradition of university-based fisheries and wildlife or natural resources departments or programs. This is, for example, the case in much of Europe, where fisheries research is traditionally structurally related to agriculture, biology, ecology, evolutionary biology or life sciences, or similar organizational units. Hence, "low-impact" fisheries science is forced to directly compete with "high-impact" basic ecological or evolutionary science. Similar developments are underway in the United States where many traditional fish and wildlife departments and colleges are being restructured to form more general biodiversity, conservation, or sustainability science schools. Consequently, fisheries scientists in Europe and elsewhere have been slowly but steadily out-selected by more basic ecological and molecular biological researchers in many departments at universities. I contend that university-based fisheries programs are in fact facing the risk of extinction. This has already happened at once-prominent European fisheries schools, such as the Imperial College in London or at Kiel University in Germany, where life scientists or evolutionary biologists have largely taken the role of traditional fisheries professors. The latter are increasingly forced to either move to foreign countries or to find a (much less independent) home in research organizations outside universities, such as in governmental fisheries laboratories. In some countries, joint ventures among university departments and nonuniversity fisheries institutes have developed that serve the dual purpose of high-quality academic research and providing science-based fisheries management and policy advice (e.g., Institute for Marine Resources and Ecosystem Studies associated with Wageningen University in The Netherlands). It is as yet not clear how stable such joint ventures will be.

Any substantial loss of fisheries professors from universities will inevitably affect the curricula of ongoing master's programs. This comes at a time where many of the traditional fisheries and wildlife programs are developing into biodiversity and conservation programs that no longer focus on fisheries or aquaculture. Master's programs in natural resources are currently transforming because their broader scope promises to generate more basic funding, more "important" publications (i.e., higher impact factor), and greater numbers of students, all aspects on which the financial backbone of most universities depend. Unfortunately, many new professor hires for these programs are no longer trained in traditional fisheries methods, such as quantitative fish stock assessment. Correspondingly, many natural resource students in universities are no longer taught the key toolbox of methods needed to advance the fisheries profession (Berkson et al. 2010). It is unlikely that the new generation of "biodiversity scientists" will be able to contribute meaningfully to sustainable fisheries other than by publishing papers on the bad state of the world's fisheries (Hilborn 2006).

POTENTIAL SOLUTIONS TO REVERT THE TRACK

For economic reasons of rational choice, loss of investments in the collective good, other than by publications, is unavoidable in the current climate of quantity-oriented research metrics. The positive message is that a rising "tragedy of the scientific commons" can be avoided by incentivizing prosocial behavior (Fischer et al. 2012b). Four changes seem crucial to me.

First, we as a scientific community would benefit from a reorientation toward the key goal of our endeavor, which is to create and disseminate relevant knowledge that matters to society rather than maximizing paper counts or citation rates as ends in themselves. Publishing is a means to an end, but not more. Within the fisheries profession, and in fact environmental science in general, we need to focus on influential work (Donaldson and Cooke 2013) that helps solving the pressing environmental challenges humanity is facing.

Second, each of us needs to work toward rebirth of a healthy academic culture. Put simply: salary, funding, and status should no longer be achieved by having a paper published in the equivalent of *Nature* or *Science* or maybe PNAS (= Post *Nature* and *Science*) or by having long lists of papers, but through the actual discussion and evaluation of factual content that an individual or project has made. We should particularly value achievements, products, and results that make a difference in the real world—in our case, contribute to sustainable fisheries. Critics will say that this is not easily quantifiable, and that is exactly right (Eyre-Walker and Stoletzki 2013). The quality of individual scholarship can probably best be judged through rigorous peer review, and this includes taking the time to read a candidate's work. I like the German Science Foundation's regulation that prohibits the mentioning of publication numbers or listing papers in curriculum vitae in grant proposals and instead demands that each individual only mentions their five most important articles. This is a very laudable development because it forces reviewers to check content rather than numbers.

Third, leaders of the scientific community need to alter the rules of the game, deliberately and permanently. This mainly involves altering the payoff structures that drive individual behavior by fostering a culture of appreciation of alternative forms of research impact (Winfield 2010). Impactful prosocial activities include quality publications, quality teaching and student supervision, quality review activities, committee work, outreach, and very important, engagement with civil society through transdisciplinary research or other means to help solving pressing societal issues such as those presented by overfishing. These contributions should not be valued as ancillary to technical papers but on equal footing. Put simply: research organizations and funding agencies need to sustain and value the many scholarly efforts that are needed for long-term maintenance of cutting-edge research programs, even if those efforts (e.g., reviewing, advising an agency) currently do not confer the same status as the technical papers that emerge from such cutting-edge research.

Finally, deans and hiring committees are well advised to seek a diversity of research staff in terms of gender and complementary competencies rather than hiring paper-based rock stars only. Similar to the portfolio effect in finance and natural ecosystems (Schindler et al. 2010), diverse teams produce better decisions and are likely to complement each other optimally to allow less steep but sustainable growth of a research organization. Key in this context is the promotion of researchers who unselfishly excel by helping others solving science-related issues, which has been found to elevate the research quality of entire research units (Oettl 2012).

Without purposeful intervention in the four areas just mentioned, I contend that individually rational behavior that does not pay attention to wider societal effects is bound to produce many irrelevant papers that are published for the sake of publishing but do not advance the knowledge base, while at the same time producing important costs to the scientific system and society at large that are no longer trivial. Erosion of scientific integrity (Hayer et al. 2013), decline of university-based fisheries programs, and unsustainable fisheries will be among them.

ACKNOWLEDGMENTS

I thank Mike Allen and the fisheries group at the University of Florida and Steven Cooke, Rob Ahrens, John Post, Kai Lorenzen, Hans-Peter Grossart, Mark Gessner, Rita Adrian, Jens Krause, David Hewitt, and three anonymous reviewers for discussions and comments. A first version of this essay was written while on sabbatical at the University of Florida. I thank Mike Allen and Mendy Willis for their outstanding hospitality and Mike for the tarpon fishing trip and the many chats over this essay and many other issues while fishing.

REFERENCES

Adler, N. J., and A.-W. Harzing. 2009. When knowledge wins: transcending the sense and nonsense of academic rankings. Academic Management Learning Education 8:72–95.
Alberts, B. 2013. Impact factor distortions. Science 340:787.
Berkson, J., S. F. Hudy, S. L. McMullin, B. R. Murphy, M. H. Prager, M. J. Kelly, and N. B. Thompson. 2010. Addressing the shortage of stock assessment scientists through undergraduate workshops. Fisheries 34:220–227.
Bohannon, J. 2013. Who's afraid of peer review. Science 342:60–65.
Brembs, B., K. Button, and M. Munafó. 2013. Deep impact: unintended consequences of journal rank. Frontiers in Human Neuroscience 7:291.
Donaldson, M. R., and S. J. Cooke. 2013. Scientific publications: moving beyond quality and quantity towards influence. BioScience 64:12–13.
Eyre-Walker, A., and N. Stoletzki. 2013. The assessment of science: the relative merits of post-publication review, the impact factor, and the number of citations. PLOS Biology 11:e1001675.
Fischer, J., E. G. Ritchie, and J. Hanspach. 2012a. Academia's obsession with quantity. Trends in Ecology and Evolution 27:473–474.
———. 2012b. An academia beyond quantity: a reply to Loyola et al. and Halme et al. Trends in Ecology and Evolution 27:587–588.
Hardin, G. 1998. Extensions of the tragedy of the commons. Science 280:682–683.
Haslam, N., and S. M. Laham. 2010. Quality, quantity, and impact in academic publication. European Journal of Social Psychology 40:216–220.
Hayer, C.-A., M. Kaemingk, J. J. Breeggemann, D. Dembkowski, D. Deslauriers, and T. Rapp. 2013. Pressures to publish: catalysts for the loss of scientific writing integrity? Fisheries 38:352–355.
Hilborn, R. 2006. Faith-based fisheries. Fisheries 31:554–555.
Jensen, O. P., T. A. Branch, and R. Hilborn. 2012. Marine fisheries as ecological experiments. Theoretical Ecology 5:3–22.
Kaushal, S. S., and J. M. Jeschke. 2013. Collegiality versus competition: how metrics shape scientific communities. BioScience 63:155–156.
Lawrence, P. A. 2007. The mismeasurement of science. Current Biology 17:583–585.
Lockwood, J. A., D. S. Reiners, and W. A. Reiners. 2013. The future of ecology: a collision of expectations and desires? Frontiers in Ecology and the Environment 11:188–193.
Macilwain, C. 2013. Halt the avalanche of performance metrics. Nature 500:255.
Neff, N. D., and J. D. Olden. 2006. Is peer review a game of chance? BioScience 56:333–340.
Oettl, A. 2012. Honour the helpful. Nature 489:497.
Schäfer, R. B., S. J. Cooke, R. Arlinghaus, N. Bonada, F. Brischoux, A. F. Casper, J. A. Catford, and V. Rolland. 2011. Early career researchers' perspectives on the current and future state of the scientific publication process in ecology—a response to Statzner & Resh (2010). Freshwater Biology 56:2405–2412.
Schekman, R. 2013. How journals like *Nature*, *Cell* and *Science* are damaging science. The Guardian 9 December. Available: http://www.theguardian.com/commentisfree/2013/dec/09/how-journals-nature-science-cell-damage-science. (April 2014).
Schindler, D. E., R. Hilborn, B. Chasco, C. B. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. Nature 465:609–612.
Ségalat, L. 2010. System crash. EMBO Reports 11:86–89.
von Humboldt, W. 1986. Ideas about an attempt to identify the boundaries of the efficiency of the state (Ideen zu einem Versuch, die Grenzen der Wirksamkeit des Staats zu bestimmen). Reclam, Stuttgart, Germany.
Weingart, P. 2005. Impact of bibliometrics upon the science system: inadvertent consequences? Sientometrics 62:117–131.
Winfield, I. J. 2010. Meeting across the river: from science to impact. Aquatic Conservation: Marine and Freshwater Ecosystems 20:607–610.

Global Inland Fisheries Conference: Call for Abstracts

The organizers of **Freshwater, Fish, and the Future**, an international conference to be held 26–30 January 2015 at the headquarters of the Food and Agriculture Organization of the United Nations in Rome, Italy, are pleased to announce the Call for Abstracts.

Contributions for oral or poster presentations are welcome. The Global Inland Fisheries Conference will take a groundbreaking, global, multidisciplinary approach to inland water issues with a focus on fish and fisheries for food security, livelihoods, and their role in aquatic ecosystems. A cross-sectoral effort to raise the profile of inland fisheries, the conference seeks to better incorporate fish into agricultural, industrial, recreational, and urban land use and water resource planning through development of improved assessment frameworks and value estimation in the context of global change adaptation. Abstracts should address one of the four conference themes and include a discussion about possible future scenarios. These four themes are described fully on the conference website at www.inlandfisheries.org:

1. Biological assessment
2. Economic and social assessment
3. Drivers and synergies
4. Policy and governance

Potential contributors should submit an abstract by **10 August 2014** using the instructions and online submission form at www.inlandfisheries.org. The Editorial Committee will review all abstracts for relevance to the conference and scientific merit before compiling the program. Notifications of acceptance, along with potential publishing opportunities, will be sent by 1 October 2014.

Freshwater, Fish, and the Future is organized by Michigan State University and the Food and Agriculture Organization of the United Nations. For more information about the conference, see www.inlandfisheries.org. Follow Global Inland Fisheries Conference news on Twitter (https://twitter.com/InlandFisheries), Facebook (www.facebook.com/inlandfisheries), and LinkedIn (www.linkedin.com/groups/Global-Inland-Fisheries-Conference-7402542/about).

Why Open Source GIS Software Is Not For Me

Thom Litts

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Thom Litts

The November 2013 issue of Fisheries *had a great article—and some interesting findings—on the use of geographic information systems (GIS) in fisheries management agencies (Eder and Neely 2013). I wasn't surprised to find a listing of mature open-source GIS projects, nor was I surprised that the overwhelming majority of survey respondents are aligned with ESRI, a commercial GIS software provider. But the article got me thinking, and on the heels of the Quantum GIS 2.0 (QGIS) release in September 2013, I asked a colleague why we weren't looking to QGIS to support our field biologists. A couple weeks later, after some thought, research, and testing, the following arrived in my Inbox. Enjoy!*

Why Open Source GIS Software Is Not For Me
An Essay by M. Riley, GIS Specialist, GISP

Several free and open-source software (FOSS) GIS projects have been developed and improved upon by their user community input and altruistic programmers' code in the ongoing pursuit of creating GIS software for the masses that is comparable to commercial packages. The nascence of some FOSS was coincident with industry giants like ESRI and ERDAS and they are used today by private industry, universities, and governments throughout the world.

FOSS GIS also include spatial enterprise database management, geographic data server, and web GIS software, which has improved exponentially over the last few years. Rent some cloud server space and you can have a full enterprise GIS, including web mapping services for a fraction of the $80–100K that it would cost if using proprietary software and your own server(s). The savings persist in subsequent years in license renewals, maintenance fees, and hardware upgrades.

However, the wide use and cost savings do not easily sway me to switch to open-source solutions or to convince my coworkers to do likewise. I rely greatly on the complexities of commercial software to keep GIS novices in the dark and afraid of the technology, thus increasing my own job security.

What the neophytes do not know is that mature, open-source GIS software is user-intuitive and provides a suite of tools that are commonly needed because this software was created for users by users of the software without any commercial-driven pressure to throw in everything but the kitchen sink. I count on obfuscation in proprietary software where it can be a challenge just finding the tool; therefore, my assistance may be required. Once found, it may not cooperate for some arcane reason and would again inevitably require my intervention.

What if the tool didn't work because there was a bug? Well, that's what paid maintenance is for. I get to spend a lot of time on hold or e-mailing back and forth with a tech who may know even less than I do about the tool's functionality. With many FOSS products, if you need help with a tool or would like to see an improvement, you can directly contact the programmers. This is too touchy-feely for me; I'd rather burn my time reading canned e-mail replies that suggest trying things that I already told them I've tried.

To help light GIS users complete their tasks, their processes can be automated. "But wouldn't automation free up your time?" In the near term, yes, but as soon as the commercial software is upgraded, my tools might be dead as a doornail, and I'm back in business. Discarded objects, changed object parameters, and deprecating a common, still-extant programming language have caused GIS professionals to reprogram their customizations at their vendor's whim. And it has occurred more than once—anyone ever heard of Avenue or VBA?

I rely greatly on the complexities of commercial software to keep GIS novices in the dark and afraid of the technology, thus increasing my own job security.

Of course, you usually cannot have two versions of the same commercial software simultaneously installed on a machine. To salvage the programming, at least one computer must be left behind to run the older version—until lack of support and system changes forces an upgrade. Generally, with open-source packages multiple versions can run on a single machine—and for as many years as your operating system will allow. This is not good because it makes my tools usable for a very long time—and easily sharable outside of my own office. That is way too productive; I'd rather reinvent the wheel every three years or so.

So … please ignore the several mature, open-source GIS solutions out there that can rival their commercial counterparts—the longer the general user is oblivious to the alternatives, the more work I will have on my plate. More open-source training opportunities, increasing documentation in trade and academic journals, web manuals, and forums are making it

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COLUMN
The Communication Stream

Developing Communication Policies That Work

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A few years back, a number of colleagues and I were sitting around a conference table in my office for a working lunch strategy/planning conference call with a client. I was busy pecking out notes on the keyboard, another colleague was quietly eating his sandwich, while another coworker was exercising her brain by moving her hands knitting a (quite remarkable) scarf. I was struck by how professional, yet comfortable, we all were in this setting. I took a picture and tweeted it out, noting how wonderful it was to work with such great colleagues at a respected firm while also enjoying ourselves. The trouble was—without a clear understanding of where the value was in getting the word out about a great company culture—my tweet wound up making the owner of the firm a little uneasy. After explaining my reasoning behind the tweet, hearing a different perspective from management, and realizing that there were no communication guidelines for the company, I set about developing a policy that could help alleviate future communication misgivings.

A good communication policy will set the tone for engagement and interaction, help minimize potential problems before they arise, and better support the values central to your organization.

How to set about developing a communication policy *can* feel onerous—it initially did for me. It need not be, however. A quick search of the web yields a surplus of existing policies that are relatively easy to adopt or adapt. Which policies make the most sense to use depends on your individual or business communication strategy. If strict discretion is the *modus operandi*, adopting policies that set clear guidelines (do's and don'ts), are necessarily restrictive, and lay out disciplinary procedures may be appropriate to preserve confidentiality (and appearances), protect against liability, and comply with the law.

Many scientists and science organizations/agencies, however, have missions of conducting and *communicating* science. If the name of the game is encouraging communication, collaboration, data sharing, discovery, content development, and publishing, adopting polices that are more permissive may be entirely appropriate. Thankfully, there are numerous, relatively "open" corporate and agency policies widely available on the web that can serve as a foundation from which to start. Two of the earliest (and, not coincidentally, the most permissive and *best*) corporate policies on social media come from IBM and Intel. Each developed relatively short, accommodating policies—largely free of legalese—that have been widely adopted and still serve as the definitive models. After an initial spate of overly restrictive closed-door policies (many organizations were wary of new ways of communicating), businesses and the public sector increasingly recognized the value of social media and began adopting policies that were progressively more permissive. Within the scientific community, arguably the most influential social policy in recent years was the National Oceanic and Atmospheric Administration's (NOAA) groundbreaking Scientific Integrity policy. After years of requiring scientists to work with legal and communication departments *before* talking with the media or the public about job-related work, NOAA's new policy provided guidance but essentially removed the handcuffs from agency scientists allowing them to communicate freely about their work with anyone. Though a bit lengthy, the Department of Energy has a valuable social media policy packed full of good information. The Oregon Chapter of the American Fisheries Society also has an informative social media policy that is currently being considered for adoption at the national level.

Good communication policies set the foundation for expectation, encourage employees to participate (which can help spread your message and grow your "brand"), reward positive interactions, and educate staff on appropriate personal and professional online behaviors. Regardless of which communication policies you consider adopting, incorporating several basic components will help ensure their success.

Strategy is key. If you have not already done so, identifying a list of values central to you or your organization will be invaluable as you craft your communication strategy and help ensure your social media align with your overall strategy. In an increasingly open world, policies that reflect your business strategy are likely to lead to successful use of social media. Social media policy is much more than just about the rules—it's about the strategy.

Reference existing codes of conduct. Your organization likely has an existing code of conduct and ethics guidelines that are an excellent resource. Following these existing codes and guidelines will facilitate adoption and understanding.

Don't reinvent the wheel. The Internet is full of existing policies that you can emulate. Leverage those resources and

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Trends and Directions in Water Quality and Habitat Management in the Context of the European Water Framework Directive

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The Water Quality Section is providing a series of topics throughout 2014 to highlight the diverse array of topics our members are interested in and encourage others to become members. Our members are interested in watershed, aquatic habitat, and water quality concerns and the following article is another topic presented as part of this series. For more information visit our webpage at fisheriessociety.org/wqs.

High water quality and healthy aquatic ecosystems are closely linked to human well-being (e.g., Geist 2011), making sustainable management of these resources a worldwide priority. The ecosystem functions and values derived from water bodies are linked to their direct and indirect use. They depend on water and habitat quality as well as the quality of biological communities and the public value of the water body as evident from the need of public water supply, commercial and recreational fishing, swimming, or boating (Figure 1). This article presents trends and directions in European water quality and habitat management and reviews Europe's most important legal basis, the Water Framework Directive (WFD).

In Europe, water quality management, and in particular the reduction of nutrient loads, has been the core target of water policies in the second half of the twentieth century. Due to the replacement of phosphorus (P) in laundry detergents and improved sewage collection and treatment systems that effectively removed P, the nutrient loads to most European water bodies have been drastically reduced. For instance, in Lake Constance, one of Europe's largest lakes, total-P levels have decreased 90% compared to eutrophication levels in the 1970s. Current challenges in water quality management in central Europe include the increase in biogas production with leakage accidents increasing the number of fish kills in recent years, as well as the effects of xenobiotic substances in water bodies (Connon et al. 2012). Switzerland has begun to add an additional (fourth) step to sewage treatment to effectively reduce the concentrations of these minimally biodegradable substances in surface waters. Despite the remaining challenges, water quality has greatly improved in almost all of Europe.

The situation for habitat quality is more problematic since most of the European water bodies have undergone severe structural modification due to the long period of settlement and use of water bodies by humans. In particular, stream ecosystems are strongly impacted by habitat fragmentation caused by dams and weirs (e.g., on Europe's largest river system, the Danube on average every 4 km), as well as by a lack of instream structural

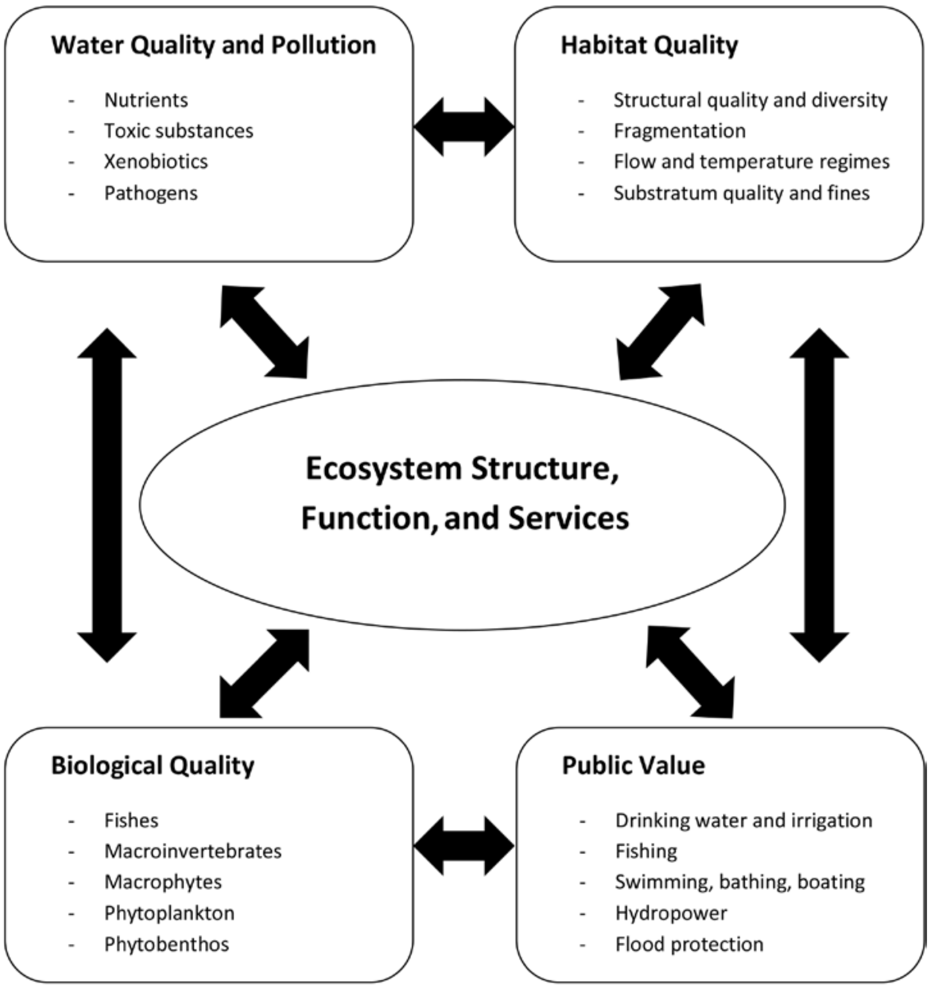


Figure 1. The interaction between ecosystem functioning, functions, and services with examples of water quality, habitat quality, biological quality, and the public value of water bodies.

diversity, channelization, and an increased introduction of fine sediments from the catchments due to changes in land use (Geist 2011).

All of the above impacts have direct or indirect consequences on the biological quality components (Figure 1), where the status of typical stream fishes seems to be most at risk compared to other communities. Similar to the situation in North America, more than a third of the European freshwater fish species (including an even greater percentage of rheophilic and gravel-spawning fishes), as well as more than two-thirds of the European freshwater mussel species, are considered threatened or near threatened. These numbers clearly point at major ecological deficits in European water bodies that need to be addressed. Most of Europe is densely populated, and there are many constraints for restoration (e.g., due to flood protection or required groundwater level maintenance). In addition, new ecological pressures such as increased hydropower production have emerged. Thus, a clear definition of conservation priorities based on public consensus is needed.

In Europe, a fundamental change in the approach to monitoring, protecting, and restoring water and habitat quality has recently emerged. This has been primarily driven by the European WFD (European Parliament 2000), which classifies the status of aquatic ecosystems into five classes (high, good, moderate, poor, and bad) based on biological, hydromorphological, and chemical characteristics. The core objective of the WFD is that the ecological status of all water bodies (or the ecological potential in case of highly modified water bodies) attains a "good" designation by 2015. The WFD is the first piece of legislation in Europe that provides protection for all water systems from source to sea (including groundwater, rivers, lakes, estuaries, and coastal waters) as well as their habitats and the species that occur in them. In contrast to conventional administrative water management systems in Europe, the focus on the management of entire catchments (so-called river basin management plans) is a novel approach. This approach has required harmonization and intercalibration across European member states, as well as active involvement of stakeholders and the public, to produce a program of measures to reduce the risk to water bodies and to help them attain good status. In addition to the desired water and habitat quality improvement, preventing the deterioration of a water body from one status class to a lower one is also important. In the WFD, the characterization of water bodies is based on their typology and conditions in a pristine state (reference conditions), which sets the benchmark for good ecological status of each type of surface water. At the same time, pressures and impacts of human activity need to be assessed. In the case of biological assessments (data on fishes, macroinvertebrates, macrophytes, phytoplankton, phytobenthos), results are expressed as ecological quality ratios, which are based on the comparison of monitoring data with reference condition. WFD's overall objective for many of the European water bodies of reaching a good status (or good potential) by the end of 2015 is highly ambitious and not attainable, especially due to target failures in the biocomponent "fishes," which is strongly affected by migration barriers. After first producing a river basin management plan, two 6-year cycles of review, reassessment, and revision will provide opportunities for adaptive management until 2027.

Though the holistic approach of the WFD is undoubtedly a great advancement in the management approach to aquatic ecosystems, there is also some criticism and suggestions for future adaptation. For instance, due to the invasion of nonindigenous species into many European surface waters, which has resulted in pronounced ecosystem shifts (e.g., Keller et al. 2011; Brandner et al. 2013), the use of biological reference conditions that are unlikely to ever be met in the future has become controversial. The WFD goals have been criticized as too ambitious and the huge amount of monitoring data is not centrally stored and thus poorly accessible for purposes beyond the WFD (Hering et al. 2010). Another main challenge is improved understanding of the effects of restoration measures through use of ecological indicators. Restoration measures can be important tools in achieving the objectives of the WFD yet are often based on gut feeling rather than on scientific evidence (Pander and Geist 2013).

In conclusion, European policy has taken an important step toward a more holistic and ecologically oriented international management of water bodies. The great remaining challenges for habitat and community restoration require refinements of conservation priority settings, a better understanding of restoration effects, and transdisciplinary collaboration of natural scientists, engineers, politicians, and stakeholders.

REFERENCES

Brandner, J., A. F. Cerwenka, U. K. Schliewen, and J. Geist. 2013. Bigger is better: characteristics of round gobies forming an invasion front in the Danube River. PLoS ONE 8:e73036.

Connon, R., J. Geist, and I. Werner. 2012. Effect-based tools for monitoring and predicting the ecotoxicological effects of chemicals in the aquatic environment. Sensors 12:12741–12771.

European Parliament. 2000. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the community action in the field of water policy. Official Journal of European Union 327:1–73.

Geist, J. 2011. Integrative freshwater ecology and biodiversity conservation. Ecological Indicators 11:1507–1516.

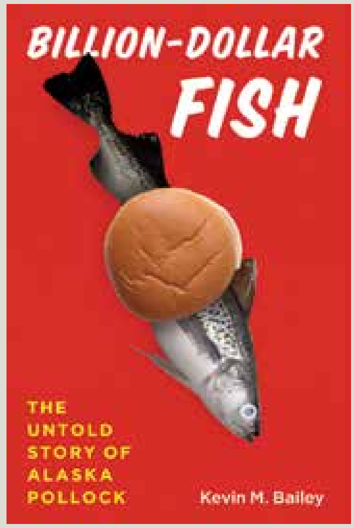
Hering, D., A. Borja, J. Carstensen, L. Carvalho, M. Elliott, C. K. Feld, A.-S. Heiskanen, R. K. Johnson, J. Moe, D. Pont, A. Lyche Solheim, and W. van de Bund. 2010. The European Water Framework Directive at the age of 10: a critical review of the achievements with recommendations for the future. Science of the Total Environment 408:4007–4019.

Keller, R. P., J. Geist, J. M. Jeschke, and I. Kühn. 2011. Invasive species in Europe: ecology, status and policy. Environmental Sciences Europe 23:1–17.

Pander, J., and J. Geist. 2013. Ecological indicators for measuring stream restoration success. Ecological Indicators 30:106–118.

Billion-Dollar Fish: The Untold Story of Alaska Pollock

Kevin M. Bailey. The University of Chicago Press, Chicago, Illinois. 2013. 271 pages. US$25.00 (hardcover), $18.00 (e-book)



Consumers are becoming more interested in knowing what species of fish they are eating, where their fish came from, and whether the fishery is sustainable; yet, the most consumed fish in the United States is rarely known by name, let alone whether its fishery is sustainable. What do McDonald's Filet-o-Fish sandwiches and California sushi rolls often have in common? Alaska (Walleye) Pollock (*Theragra chalcogramma*). By weight, it has the highest catch in the United States each year and has been at the top globally. Given the immensity of the fishery, why has this species largely gone unnoticed to most lay audiences? Partly because the name rarely occurs in association with the protein product it ultimately becomes. Other reasons are the lack of coverage in the popular media and the lack of a general audience book on Alaska Pollock.

In *Billion-Dollar Fish*, Kevin Bailey fills that void. This book has similar traits (coverage of history, biology, management, and conservation) as other general audience books on fish (*The Founding Fish*, *Cod*). Unlike those books, however, the author of *Billion-Dollar Fish* is a top marine fisheries ecologist who has researched Alaska Pollock since he was a fisheries biologist observer on a Japanese fishing vessel during the 1970s.

Bailey does an excellent job describing the biology and ecology of the species he has spent much time researching, but he goes well beyond these topics. Bailey describes the fishery from the perspectives of the fishermen, politicians, environmentalists, and scientists. These perspectives are pieced together from books, scientific papers, popular press articles, and Bailey's recollections. Additionally, these perspectives are masterfully brought to life through in-depth interviews, and Bailey's descriptions give the reader a sense of being present at the interview while experiencing the emotions of interviewer and interviewee.

In addition to learning about an important fish species and the people involved in the fishery, Bailey describes the collapse of an Alaska Pollock population in the central Bering Sea during the 1980s. Tremendous catches were removed from these international waters before any regulations could be put into place. Bailey ranks this collapse as one of the largest on record in the Northern Hemisphere. I suspect that many who consider themselves knowledgeable about fisheries issues will be surprised that a population of Alaska Pollock collapsed (given that this species' fishery is an example of a well-managed one and that a collapse of this magnitude occurred without them ever knowing).

An overarching biological and ecological theme of this book is how little we know about the fish that we harvest from the ocean and the difficulty that we as scientists have in estimating stock size and catch limits. Several other themes of the book include Bailey's development as a fisheries biologist and ecologist that occurred parallel to the development, maturation, and collapse of the Alaska Pollock fishery; contrasting perspectives that are dependent on a person's role in a fishery; interaction between fisheries and politics—money from industry to politicians to ensure access to the resource; the pollock fishery transition from individual fisherman to corporations; catch share programs and the nuances between "owning a public resource" and "owning the rights to fish a public resource"; and how environmental groups differ in their methods to achieve fish conservation and their impact on the fisheries management process. One point is made clear: fisheries are a complex mix of multiple players with differing agendas, which makes fisheries management extremely difficult.

Given its interdisciplinary coverage, this book would be appropriate for readers interested in the environment, conservation, history, politics, policy, biology, oceans, and fishing. Readers will appreciate the pictures, figures, and sidebars throughout the book. The sidebars cover a variety of topics from early trawling to excerpts from a Dutch Harbor, Alaska, police blotter. *Billion-Dollar Fish* could be used as a case study in undergraduate or graduate courses in fisheries and conservation biology or in other disciplines such as economics, management, and social sciences.

Bailey ends by discussing the future of the fishery providing recent fishing reports and status of the eastern Bering Sea Pollock stock. This stock's future story is uncertain and will depend on the strength of relatively few year classes. The untold story of Alaska Pollock has been told—for now.

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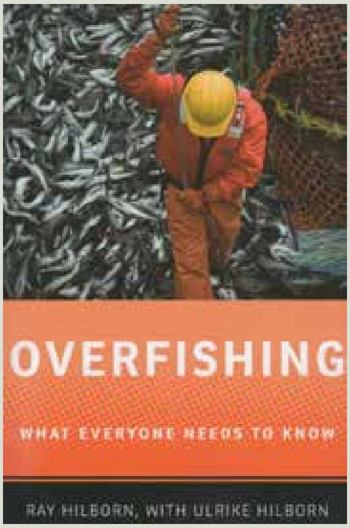


Overfishing: What Everyone Needs to Know

Ray Hilborn with Ulrike Hilborn. Oxford University Press, New York. 2012. 130 pages. US$74.00 (hardcover), $16.95 (paperback)

Overfishing: What Everyone Needs to Know is a summary of the topics and definitions associated with the sometimes controversial subject of intense fishing from the world's oceans, and could easily be called: *A Layperson's Guide to Understanding Overfishing*. This book is part of the "What Everyone Needs to Know" series, which uses a question and response format to guide readers through the issues surrounding the topic of interest. We found the format somewhat constraining for a complex issue such as this one. The chapters in Hilborn's book can be divided into two categories: those that thoroughly detail one case study related to the topic of that chapter, and those that briefly cover several examples or topics related to the subject of the chapter. Each type of chapter has its strengths and weaknesses, either providing a very narrow and detailed focus, or a broad but brief overview. Both approaches often leave the reader feeling that the topic was not adequately covered, and at times with a skewed perception of the subject.

The book encompasses many topics in the realm of overfishing, from historical impacts to current recovery and management of fisheries. Examples of case studies include the harvesting of whales to describe "Historical Overfishing" and the Orange Roughy fishery to describe "Deepwater Fisheries." Conversely, the chapters on "Economic Overfishing" and "Marine Protected Areas" discuss their topics more generally, whilst using detailed definitions. Generally, we found that the broader overview approach allowed for clearer explanations of the subject matter than the case study method, but adding a specific example in the more general chapters would have provided better illustration of the topic. The case study chapters were easier to relate to and provided an appropriate example for the subject. However, by not providing a broader context, we felt that the discussion was too narrow and misled the reader about the breadth of the chapter's focus.

The first two chapters described the history of overfishing and employed whale harvesting as an example. Chapters 3 and 4 encompassed recovery and management of fisheries, to convince readers that not all hope is lost for global fisheries. Chapter 5 covered the economics of fishing to demonstrate that overfishing is influenced by social, as well as biological factors. Chapter 6 discussed climate and fisheries, more briefly than we thought appropriate, but arguably adequate given the intent and length of the text. Chapters 7–11 highlighted the differences among various fisheries: mixed, high seas, deepwater, recreational, and small-scale and artisanal. Most of these chapters provided a specific example within each type of fishery, which would have been sufficient if a thorough definition of each fishery was given at the beginning of the chapter. The examples were appropriate, but improperly gave the impression that each fishery was characterized by one representative species. Chapters 12–15 covered illegal fishing, trawling impact, marine protected areas, and overall ecosystem impacts. These chapters were more supportive and defensive of current fishing practices. However, in certain instances this viewpoint appeared biased against those who believe overfishing is detrimental to the ocean ecosystem. The final two chapters together provided an adequate summary and synthesis of the book, leaving us with a well-rounded understanding of the status of overfishing around the world.

The depth and breadth of this book would most likely appeal to a reader with an interest in fishing, ecology, or natural resource management, but lacking significant background knowledge or experience in the topic. This book, and likely the series in general, is an appropriate way to provide a more balanced perspective to the non-expert who would otherwise receive information from other sources. Overall, *Overfishing* is a quick read and provides general information for those curious about the topic. The question and answer format and style of the book make the topic more accessible to the average reader, yet the incompleteness or lack of response to several of the questions makes this format less than ideal when discussing contentious issues such as overfishing. Furthermore, the complexity of overfishing may hinder attempts to create such a short summary. We felt that many of the chapters could have benefitted from minor formatting improvements to provide the reader with a more cohesive and informative view. Hilborn is obviously well-versed and experienced in this topic, and his book provides essential information to someone who is concerned about overfishing of the world's oceans. The book fills a niche in the market to make this often technical information more accessible to the general public, but not in an ideal format.

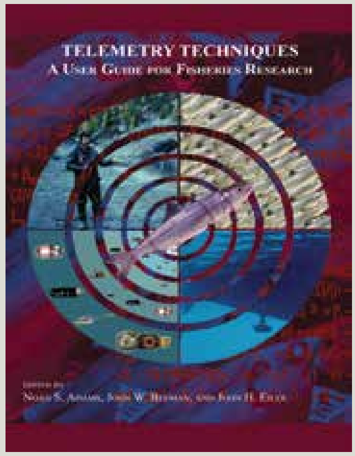
This review is the product of a collaborative effort among graduate students in a fisheries class.

Cayla Naumann, James P. W. Robinson, Cameron Freshwater, Eric Hertz, David Stormer, Amy K. Teffer, and Francis Juanes

Department of Biology, University of Victoria, Victoria, BC, Canada

Telemetry Techniques: A User Guide for Fisheries Research

Edited by Noah S. Adams, John W. Beeman, and John H. Eiler. 2012. American Fisheries Society, Bethesda, Maryland. 2012. 543 pages. US$79.00



I would have greatly benefited from reading this book at the start of my Ph.D. It is a thorough and well-organized "Telemetry 101" for students and senior researchers alike. Covering the extensive theory and application of radio and acoustic telemetry, this volume is a must-read for anyone interested in following fish. The lessons learned within could be applied to other aquatic or terrestrial species as well. It is unique in its depth; it begins with the very basics, providing a complete background on the physics and engineering involved in the methods. Study design, attachment techniques, and data analysis are described in equal detail. Readers will gain greater theoretical understanding, which will likely yield more effective research.

There is an incredible range of skills required in fish telemetry work. From construction to surgery, boat mechanics to human psychology, it is a life-long learning process with frequent technological advancements. Previously, textbook resources on fish-telemetry methods included the decades-old *Fish-Marking Techniques: Proceedings from the International Symposium and Educational Workshop on Fish-Marking Techniques* (Parker et al. 1990) and two chapters in *Fisheries Techniques* (Murphy et al. 1996). The proceedings of other conferences, such as the *International Fish Telemetry Conference* (previously the *Fish Telemetry Conference Held in Europe*) and the *International Symposium on Tagging and Tracking Marine Fish with Electronic Devices,* provide more recent examples of telemetry use, but lack the thorough methodological and theoretical background found in *Telemetry Techniques*. Journal articles may offer sufficient detail, but tend to have a narrow focus—e.g., fish surgery techniques (Jepsen et al. 2002; Mulcahy 2003). The field has been waiting for an up-to-date, comprehensive handbook outlining the basics, and as such, *Telemetry Techniques* is a celebrated publication.

With its logical layout and coherent chapters, this book is engaging and easy to navigate. It begins with an in-depth history of fish telemetry, from the first electronic transmitters of the 1950s to the vast arrays of the present. Study design considerations and tag attachment techniques follow in the next two chapters, providing an impressive wealth of information applicable to all telemetry endeavours and exceeding the scope of anything already published.

The next four sections of the book cover radio telemetry basics and case studies, and acoustic telemetry basics and case studies. The theoretical chapters describe how radio and acoustic signals are generated by the transmitters, how antennas and hydrophones detect the signals, and everything that may play a role in-between. They include instructions on designing arrays, estimating detection efficiencies, and maximizing the effectiveness of telemetry equipment. The broad variety of case studies from around the world illustrate telemetry methods specific to rivers, lakes, coastlines, and open-ocean areas. Stationary and mobile receiver methods are discussed. The book gives particular emphasis to research involving hydroelectric dams, offering expert advice on how to overcome the challenges unique to these study sites.

A section tackling data management and analysis wraps up the volume. Mark-recapture models for estimating survival are outlined, as are real-time data systems and fish passage evaluations. The quality assurance plan proposed by Hardiman et al. recommends that all data requirements and analyses be determined prior to data collection. The potential for great losses in efficiency (i.e., time, money) and data quality is great in telemetry work—this plan would benefit all studies by minimizing such losses.

Telemetry Techniques is a complete guide to radio and acoustic telemetry methods. My only criticism is their omission of the rest of the telemetry spectrum (e.g., conventional, satellite, archival tags). I would be very interested in reading a sequel that describes these other methods with the level of detail contained in *Telemetry Techniques*. For brief descriptions of the other methods, see the recently published proceedings *Advances in Fish Tagging and Marking Technology* (McKenzie et al. 2012). *Telemetry Techniques* is bound to be a resident of the fish researcher's office shelf for years to come. This manual offers extensive advice on how to plan and execute a telemetry project from start to finish, facilitating quality science for fish researchers.

REFERENCES

Jepsen, N., Koed, A., Thorstad, E. B., and E. Baras. 2002. Surgical implantation of telemetry transmitters in fish: how much have we learned? Hydrobiologia 483:239–248.

McKenzie, J., Parsons, B., Seitz, A., Kopf, R. K., Mesa, M., and Q. Phelps, editors. 2012. Advances in Fish Tagging and Marking Technology. American Fisheries Society Symposium 76. 560 pp.

Mulcahy, D. M. 2003. Surgical implantation of transmitters into fish. ILAR Journal 44(4):295–306.

Murphy, B. R., and D. W. Willis, editors. 1996. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Parker, N. C., Giorgi, A. E., Heidinger, R. C., Jester, D. B., Prince, E. D., and G. A. Winans, editors. 1990. Fish-marking techniques: proceedings of the International Symposium and Educational Workshop on Fish-Marking Techniques, held at the University of Washington, Seattle, Washington, USA, June 27–July 1, 1988. American Fisheries Society Symposium 7. 879 pp.

Cedar Chittenden

Institute of Ocean Sciences, Sidney, BC, Canada

Mt. Shasta Hatchery, Mt. Shasta, California

What is the name of your facility, how did it get that name, and how long has it been in operation?

California Department of Fish and Game manages Mt. Shasta Hatchery, which references the hatchery's location near Mt. Shasta, and Mt. Shasta City in Northern California. Mt. Shasta Hatchery was originally called Sission Hatchery, which was named after the Sission family and has been in operation since 1888. It is currently the oldest operating hatchery west of the Mississippi River.

What fish do you raise and approximately how many? What are the fish raised for?

Mt. Shasta Hatchery raises many different species of Trout and char, including Rainbow Trout Shasta strain, Rainbow Trout Colman strain, Eagle Lake Trout, Brown Trout, and Brook Trout. Mt. Shasta Hatchery had a 94,425 pound catchable allotment and an 8,500 pound fingerling allotment for 2012. Mt. Shasta Hatchery also rears broodstock at the facility to account for 95% of the state's egg needs. Annually, the hatchery takes about 31 million eggs to meet the demand.

The fish raised at Mt. Shasta Hatchery are planted in different lakes, reservoirs, creeks, rivers, and ponds throughout the state of California to be caught by anglers. The fish planted in these bodies of water aid in sport fishery enhancement, conservation, and restoration efforts. Broodstocks are also reared here to account for the annual egg needs brought forth by other facilities throughout California.

What is the biggest challenge facing your facility today? What challenges do you foresee in the future?

The biggest challenge Mt. Shasta Hatchery faces today is triploiding trout to meet our departmental demands. Triploiding, a process of pressurizing a fertilized egg at a precise time so the egg will hatch into a sterile fish, is new to Mt. Shasta Hatchery staff. Trying to become more efficient and teach other department hatcheries the process has been our biggest challenge.

As a state-owned and -operated hatchery, we foresee our greatest challenge in the future to be budget constraints set forth by the state's financial deficit. Mt. Shasta Hatchery operates on monies generated from fishing license sales (established in 2009 as Assembly Bill 7, now Fish and Game Code 13007), but the hatchery is still affected by governed mandates of furloughs, pay, and position cuts. Operating a facility that raises a live product requires around-the-clock care and the governed mandates can adversely affect how much care is given.

The staff of the Mount Shasta Hatchery in 2011. Photo credit: Mt. Shasta Hatchery.

An example of a Shasta strain Rainbow Trout raised at the Mount Shasta Hatchery. The trout pictured here is a broodstock. Photo credit: Mt. Shasta Hatchery.

A Mount Shasta employee releases new Rainbow Trout into the McCloud River. Photo credit: Mt. Shasta Hatchery.

Any interesting trivia/facts about your facility you wish to share?

Mt. Shasta is the only hatchery in California that maintains and utilizes earthen ponds. The hatchery also supplies Hawaii with trout eggs, which are then reared and planted in a freshwater lake that is fished by locals and tourists. Mt. Shasta Hatchery stocks 59 high mountain lakes by air and assists in the stocking of another 10 high mountain lakes by horse and mule.

In one sentence, why is fish culture important?

Fish culture is important because it is essential to help maintain the integrity of our resources where otherwise sustainable populations of wild stock are unable to handle the increased demand for recreational opportunities for the constituents of California.

You can contact the Mt. Shasta Hatchery via e-mail at: mtshasta@dfg.ca.gov

Or visit their website: dfg.ca.gov/fish/Hatcheries/MtShasta

We thank Brian Rushton at Mt. Shasta Hatchery for answering our questions and providing photos. To see the complete "Better Know a Hatchery" feature for Mt. Shasta as well as other featured facilities, visit the Fish Culture Section website at: www.fishculturesection.org and click on the "Better Know a Hatchery" tab. Also, visit us on Facebook to see photos from all of the facilities featured in "Better Know a Hatchery."

University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility, Red Cliff, Wisconsin

What is the name of your facility, how did it get that name, and how long has it been in operation?

The University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility (NADF) is located in northern Wisconsin near the towns of Red Cliff and Bayfield. It was constructed in 2002–2003 and has been operational since 2004.

What fish do you raise and approximately how many? What are these fish used for?

We have raised a variety of cool and coldwater species including: Walleye, Sauger, Hybrid Walleye, Spotfin Shiners, White Suckers, Lake Sturgeon, Lake Herring, Rainbow Trout, Lake Trout, Brook Trout, Arctic Char, and Yellow Perch.

Our fish are used for applied science and demonstration of various species for fish culture to help solve rearing issues. We also conduct various research projects for specific groups, and have been known to help out on conservation/restoration efforts from time to time. To sum it up, we perform a variety of services for many different stakeholders which include private, tribal, state, university, and federal partners.

What is the biggest challenge facing your facility today? What challenges do you foresee in the future?

Rising electric, fuel, fish feed, and maintenance costs are the biggest challenges we face today. For the future it will be the same as those we currently face, plus the need to change major infrastructure to keep up with all the changes in fish culture today.

Any recent successes or news you can share?

Since the UWSP-NADF facility was built fairly recently, with all the latest technology, it is running very well. One of the best items that the facility incorporates is the use of variable speed drives on our high-capacity wells in conjunction with the head-tank level monitor. This technology allows us to operate our wells at various speeds and flows depending on our use. The head-tank level monitor automatically adjusts the pump speed to our valve adjustments, never wasting water over the overflow like in the old days. This technology has greatly influenced the efficiency of the facility and allows us to operate in many different modes without worrying that we are wasting water or energy.

We have had good success with the rearing of Hybrid Walleye from egg to food-market size using indoor techniques and recycle water systems. Utilizing techniques that were pioneered by the Iowa DNR, with a few adjustments, we have been able to rear Hybrid Walleye (Saugeye) to market size (1.0 lb) in as little as 10 months in a recycle water system on commercially available diets. There is much interest for these fish from the private food-fish industry and we are starting to see more and more involvement.

We have had good success with rearing of Arctic Char in our coldwater recycle system from fingerling to market size (2.2 lbs) in less than 12 months. Utilizing 24-hour lighting and 54°F water, the char grow quickly and have many good aquaculture attributes such as 1:1 feed conversions, 50% fillet yield, good market acceptance and price. There appears to be interest in this fish for the food fish market by several private entities in Wisconsin.

Any interesting trivia/facts about your hatchery you wish to share?

I believe we are the only demonstration/research facility in the Midwest that operates three commercial-scale recycle systems for cold and coolwater fish species. At this point, we are

One-year-old Saugeye raised in an indoor recirculating aquaculture system. Photo credit: UWSP-NADF.

Recirculating aquaculture systems at the NADF. Photo credit: UWSP-NADF.

A large Arctic Char raised at the NADF. Photo credit: UWSP-NADF.

the only supplier of feed-trained Hybrid Walleye (Saugeye) that we are aware of, and have our own intensively grown, pellet trained, broodstock of Walleye and Sauger to help support this program.

In one sentence, why is fish culture important?

Fish culture is of great importance, if we, as a society, want to continue to provide for our ever-increasing demand for seafood, threatened/endangered fish species, and conservation fisheries projects worldwide.

You can contact the UWSP-NADF facility via e-mail at: gfischer@uwsp.edu

Or visit their website: aquaculture.uwsp.edu

We thank Greg Fischer at the UWSP-NADF for answering our questions and providing photos. To view the complete "Better Know a Hatchery" feature for the UWSP-NADF as well as other featured facilities, visit the Fish Culture Section website at: www.fishculturesection.org and click on the "Better Know a Hatchery" tab. Also, visit us on Facebook to see photos from all of the facilities featured in "Better Know a Hatchery."

ARCHIVES FROM 100 YEARS AGO!

MR. COBB, of Minnesota: We had an experience with copper sulphate, but it is not as valuable as it might be, for we do not know just what took place. In a small lake used for bathing purposes all the fish were reported dying. I went out to it and found that all the animal and vegetable life of the pond was dead or dying and discovered a substance on the shore that proved to be copper sulphate. The work was evidently done in the evening by persons having access to boats. One thing which interested me was that the horses were drinking from the lake the next morning and campers were getting their drinking water there, and it had apparently no effect on any of them.

MR. TITCOMB: That brings out very clearly the fact that the copper sulphate precipitates very rapidly. You can poison a lake very effectively and feel perfectly sure that you have not destroyed the fished in a stream below.

John W. Titcomb (1914): The Use of Copper Sulphate for the Destruction of Obnoxious Fishes in Ponds and Lakes, Transactions of the American Fisheries Society, 44:1, 20-26.

Lochie Jo Allen

Dr. J Frances Allen—Jady to those who knew and loved her—and her sister, Lochie Jo Allen, significantly influenced the development of scientific publications and women's participation in the American Fisheries Society (AFS). However, many of us may know little about how these pioneering women came to excel in the field of fisheries at a time when few women were taken seriously.

Twenty-five years ago, a number of AFS members were concerned with the lack of diversity in AFS, so the idea of the J Frances Allen Scholarship was spawned and initially backed by a sporting company that provided the initial $10,000 to endow it. Then, every year after that, like clockwork, Lochie Jo contributed significantly to the scholarship herself, both financially and by essentially pounding the pavements and manning the phones to make sure that the scholarship stayed front and center in the Society's headlights. Lochie Jo loved her sister, as well as the Society, too.

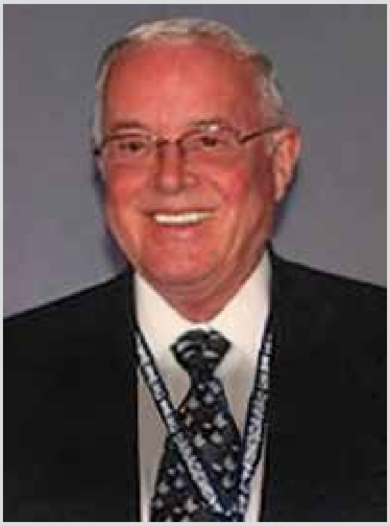
Lochie Jo Allen was a pioneer in her own right. In fact, she brought AFS Executive Director Carl Sullivan's concept for an AFS membership bulletin to reality by launching *Fisheries* magazine in 1976. At the time, her title was associate editor (1976–1983), although she truly was the first editor of the AFS flagship magazine (later the board changed the name of the position to managing editor) during the years 1976–1983. In 2013, Lochie Jo was given a certificate by the executive director of AFS that honored her for this landmark move, along with recognizing the "confidence, devotion, diligence, intelligence, and creativity given in helping the American Fisheries Society obtain this most important milestone."

On 10 February 2014, Lochie Jo Allen passed away in Front Royal, Virginia. She left a large portion of her estate to fund her sister's scholarship, proving that even after death, she continues to give.

Some* Fisheries *magazine history, according to retired AFS Publications Director Robert Kendall:

Lochie Jo was already on the AFS staff when I joined it as Transactions *editor in July 1974. At the time, we were renting space in the American Forestry Association's Washington headquarters on 18th Street, near DuPont Circle. Lochie Jo was hired by Dick Wade, the second AFS Executive Director. During the winter of 1975, we moved the AFS office to a cramped, renovated garage ("carriage house") owned by the Society of American Foresters on the former Grosvenor estate in Bethesda, pending construction of a new office building to be owned by the Renewable Natural Resources Foundation. In April, I was made acting Executive Director as well as a journal editor. In September, Carl Sullivan was hired as Executive Director during the AFS Annual Meeting in Las Vegas. Sullivan, who was Dick Stroud's second at the Sport Fishing Institute, joined AFS that November. When he joined us, it was quickly clear that with Sully's energy and projecting voice, the carriage house could not be a locus of contemplative scholarship. By late spring 1976, I had moved journal operations out of Bethesda and into my basement. I was only an occasional visitor to the AFS office for the next 10 years. Even before he took over at AFS, Sullivan was incubating the idea of a membership magazine, one geared toward fishery managers rather than scientists, to replace the dull and crusty newsletter. It took him several months before he could flesh it out, get it satisfactorily budgeted, and have it approved by the Executive Committee, by which time I was out of the day-to-day loop. I don't know why he selected Lochie Jo to handle the magazine for him, but she clearly was the most literary of the staff at that time. She dug in, and if my memory is at all correct, the two of them managed to get an issue of* Fisheries *out by the end of the year. It was not long after her retirement (a year or three?) before Sullivan and Lochie Jo began a new collaboration: a retired members' newsletter I believed to be called "Homo Piscis Rusticus." This newsletter, part of Sullivan's effort to keep retirees (and their money) more involved with the Society, lasted for two or three years before it ran out of steam. Lochie Jo maintained contact with the AFS office for several more years, most commonly during the December holiday parties. She continued to contribute money to the Society, as did Jady, and I suspect (though don't know) that she helped out in some measure with the creation of the scholarship award. The two sisters remained very close and lived together till death departed the two.*

For those who would like information on how to contribute to the J Frances Allen Scholarship Fund, please contact AFS membership coordinator Eva Przygodzki at eprzygod@fisheries.org or call (301) 897-8616 ext. 203.



Walter R. Courtenay

Walter R. Courtenay, Jr., 80, died in Gainesville, Florida, on 30 January 2014. He was born in Neenah, Wisconsin, and the family moved to Nashville, Tennessee, in 1944, where his father was pastor of the First Presbyterian Church. He completed his B.A. degree at Vanderbilt University in 1956 and his Ph.D. degree from the University of Miami in 1965.

Courtenay served as a faculty member at Duke University (1963–1965), Boston University (1965–1967), and Florida Atlantic University at Boca Raton (1967–1999), where he twice chaired the Department of Biological Sciences. At various times he also held research appointments with the U.S. Bureau of Commercial Fisheries, the Museum of Comparative Zoology (Harvard University), U.S. Fish and Wildlife Service, and Arizona State University. He served as a consultant on introduced fishes for the Fishery Resources and Environment Division, Food and Agriculture Organization of the United Nations, in Budapest and Rome in 1988; the Foundation for Research Development, Council for Scientific and Industrial Research, Pretoria, South Africa, in 1988; the South Australia Department of Fisheries, Adelaide, Australia, in 1989; and the Office of Technology Assessment, Congress of the United States, in 1991–1992. After retirement, he relocated to Gainesville, Florida, where he continued his research alongside colleagues at the University of Florida, several of whom he collaborated with on various projects and publications. In 2000, he was made a fellow emeritus of the American Institute of Fishery Research Biologists (AIFRB). In 2007, at the Annual Meeting of the American Fisheries Society in San Francisco, he was honored with the William E. Ricker Resource Conservation Award, along with the AIFRB Lifetime Achievement Award.

Courtenay was an ichthyologist and a leading authority on invasive nonindigenous fish, particularly those introduced into the United States. Among his numerous publications are *Distribution, Biology, and Management of Exotic Fishes* (1984), coedited with Jay Stauffer, and *Snakeheads (Pisces, Channidae), a Biological Synopsis and Risk Assessment* (2004), coauthored with James D. Williams. In his final years he held the position of courtesy curator for the Florida Museum of Natural History in Gainesville and research fishery biologist with the U.S. Geological Survey, Biological Resources Division, at the Florida Integrated Science Center in Gainesville.

Michael Joseph Mason

Michael Joseph Mason, 59, passed away surrounded by his family, friends, and coworkers on 24 February 2014. A 1977 graduate of Virginia Tech in Fishery Science, Mason started his career in Virginia, where he held several seasonal and full-time positions with the Virginia Department of Game and Inland Fisheries from 1974 to 1980. In 1981, Mason was hired by the Iowa Department of Natural Resources to manage the Rathbun Fish Hatchery, a facility for Channel Catfish, Walleye, and Largemouth Bass.

In the beginning, Walleye culture was especially challenging because culture techniques were still under development and the facility was designed for catfish culture. Mason's observations of Walleye survival in the hatchery with larger pond fingerlings was noted in the 1988 Coolwater Fish Culture Conference proceedings. This observation was one of the keys to successful Walleye culture at Rathbun and assisted other states. Thanks to Mason's can-do attitude and dedication to producing quality hatchery products, Iowa is now recognized nationally as a leader in Walleye culture.

In 1998, Mason's leadership skills were recognized and valued by the Department of Natural Resources when he was promoted to supervisor of the statewide Fish Culture Section. His primary responsibility as supervisor was to supervise 22 culturists at three coldwater hatcheries and three warmwater/coolwater hatcheries.

One of his employees, Donna Muhm, said, "He has been the most supportive supervisor I have ever had, his people skills are bar none. … He encourages excellence in his staff and allows them the freedom to explore new culture methods and technologies."

Mason played an important role in the management team. In addition to leading the Culture Section, Mason doubled as an assistant chief of the Fisheries Bureau. He regularly worked behind the scenes to ensure that all Fisheries Bureau teams had the resources they needed to manage Iowa's fisheries resources.

Mason was also very active at the investigational new animal drug (INAD) Coordination Workshops and served as Iowa's representative to the Drug Approval Working Group of the Association of Fish and Wildlife Agencies. His knowledge of daily hatchery operations and administrative savvy made him an excellent representative to Drug Approval Working Group and he successfully advocated for therapeutants for warm- and coolwater fish species that were reared in Iowa and by other state agencies.

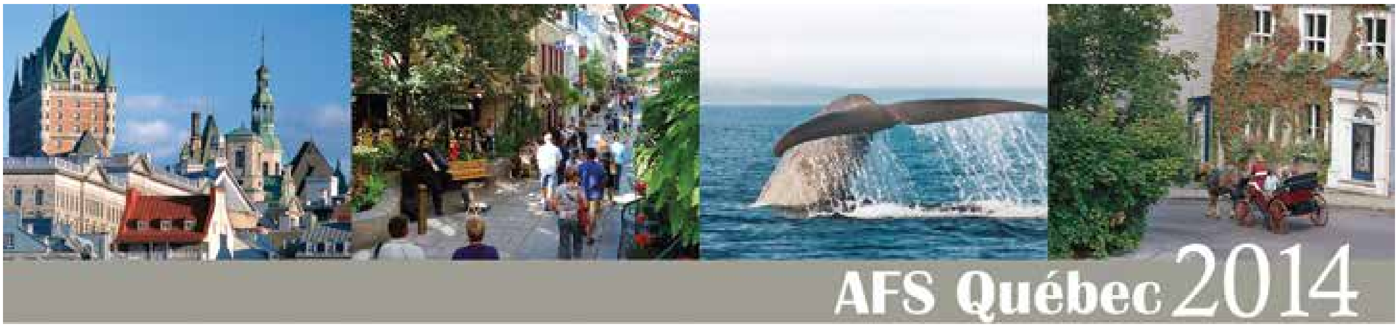
Mason was always committed to maintaining continuity of the Coolwater Fish Culture Workshop and Mid-Continent Warm Water Conference. Mason viewed these meetings as training opportunities for hatchery employees and supported their attendance to stay abreast of new fish culture research and developments. This commitment to employee development led to producing quality-size fish in the most efficient and cost-effective means. Mason was also instrumental in developing and organizing the fish trading session at the Mid-Continent meeting. The fish trades that were arranged during this session permitted many agencies to stock fish that might not otherwise be available in their state. There are undoubtedly entire sport fisheries in Iowa and elsewhere that would not exist today if it weren't for his efforts.

Mason was a devoted husband and family man and served as a foster parent to many Iowa children. His commitment and dedication for community and the environment left a substantial and lasting impact. He was also a great friend and coworker. He never had a negative attitude and will be sorely missed by all.

Mason was recently awarded the "Award of Excellence" from the Fish Culture Section of the American Fisheries Society. This very prestigious award recognized Mason for his lifetime achievement of improving fishing and fishing opportunities in Iowa. This award was presented to Mason at the October National Research Council meeting in Des Moines.

Joe Larscheid

Fisheries Bureau Chief,
Iowa Department of Natural Resources



Continuing Education Program

American Fisheries Society 144th Annual Meeting, Québec City
August 17–August 21, 2014

FREE! LEADERSHIP AT ALL LEVELS IN AFS

Steve L. McMullin, Virginia Tech; smcmulli@vt.edu

This workshop is designed for new and emerging leaders in AFS; it addresses the need for new and emerging leaders to better understand how AFS functions, the roles of unit leaders in AFS, and how to be an effective leader in an all-volunteer organization such as AFS.

BEGINNING/INTERMEDIATE GIS FOR FISHERIES BIOLOGISTS

Joanna Whittier, University of Missouri; whittierJ@missouri.edu
Student $125; Member $220; Non-member $250

This course will provide an overview of beginning/intermediate GIS skills for fisheries biologists using ArcGIS, including use of existing data, creating your own data, and review of fundamental concepts for GIS.

ADVANCED GIS FOR FISHERIES BIOLOGISTS

Joanna Whittier, University of Missouri; whittierJ@missouri.edu
Student $150; Member $220; Non-member $270

Building on the Beginning/Intermediate GIS for Fisheries Biologists course, this course will focus on geoprocessing, interpolation, and spatial analysis methods to aid in fisheries monitoring and research.

MAPPING AQUATIC HABITAT OF INLAND FRESHWATER SYSTEMS USING SIDE-SCAN SONAR

Thom Litts, Georgia Department of Natural Resources; Thom.litts@dnr.state.ga.us
Student $100; Member $150; Non-member $200

This course is an introduction to using the inexpensive Humminbird® Side Imaging system to map and quantify benthic habitats at the landscape scale. The course includes a practical session covering techniques for geoprocessing sonar imagery and map development within ArcGIS 9.x.

INTRODUCTION TO PROGRAMMING IN R FOR FISHERIES SCIENTISTS

Michael Jones, Michigan State University; jonesm30@anr.msu.edu
Student $100; Member $150; Non-member $200

This course will introduce the basics of Program R using a command-line interface and examples from fisheries research. Program R is a powerful open-source mathematical and statistical software program gaining popularity in the fisheries and ecological sciences.

INTRODUCTION TO INSTREAM HABITAT MODELING USING MesoHABSIM

Piotr Parasiewicz, Rushing Rivers Institute; riverpiotr@gmail.com
Student $100; Member $150; Non-member $200

This one-and-a-half-day course, including a field trip to a nearby stream, will serve as an introduction to modeling instream habitat using the MesoHABSIM approach and associated SimStream software and how this groundbreaking method in instream habitat modeling can be applied to river restoration and management.

RIVER MORPHOLOGY AND RESTORATION

Jim Gracie, Brightwater, Inc.; jgracie@brightwaterinc.com
Student $150; Member $250; Non-member $300

This one-and-a-half-day course covers general principles of river morphology, classification systems, hydrology and hydraulics, stream stability, natural channel restoration approaches, and a description of stabilization devices, habitat improvement devices, and performance monitoring. The material is presented with real-life examples and includes extensive class participation and problem solving.

NEW! FREE! NEW MEDIA FOR FISHERIES SCIENCE

Beth Beard, AFS Digital Content/Engagement; bbeard@fisheries.org

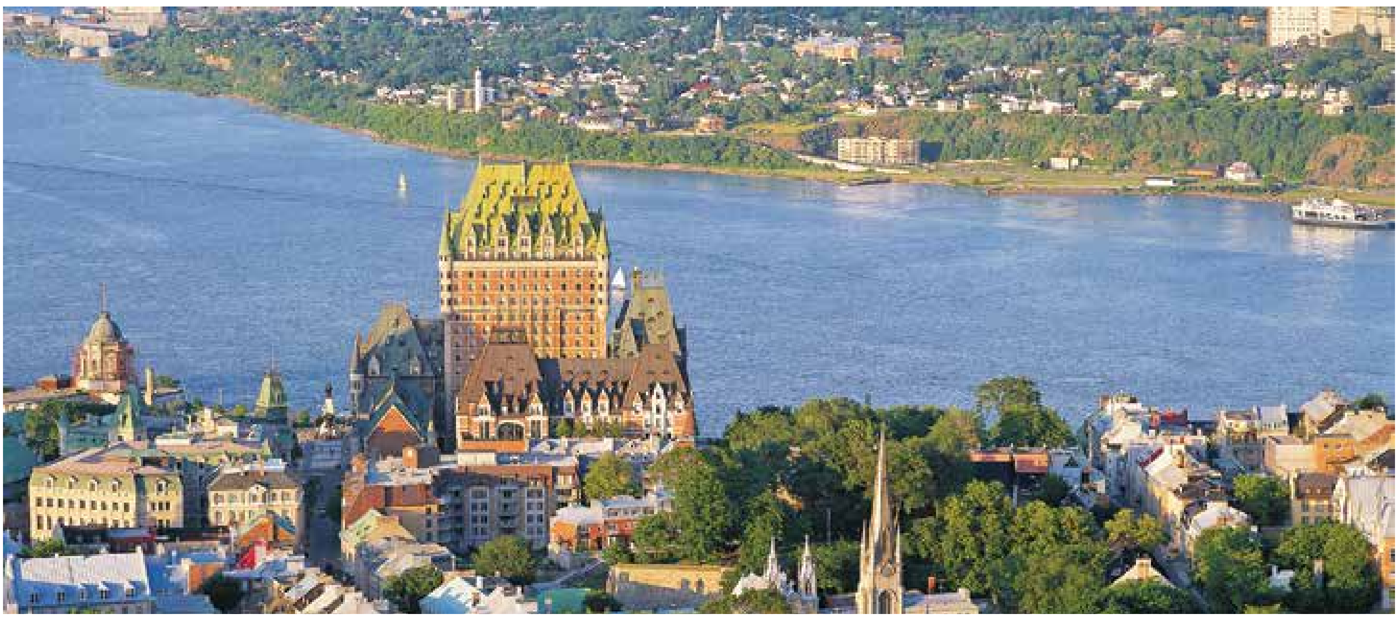
Participants in this course will be able to build a simple WordPress website, compatible with the main AFS website; learn how to create and post content to this website; and integrate website content with e-mail newsletter content, as well as social media posts. Participants will also learn various social media tools and discover how to select and use networking tools most appropriate for a given situation.

Technology Workshop

FREE! VEMCO ACOUSTIC TELEMETRY TECHNOLOGY

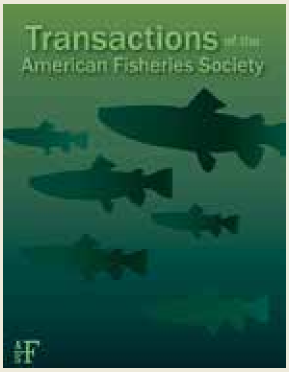
Nancy Edwards, VEMCO; nancy.edwards@vemco.com

VEMCO staff will discuss passive and active acoustic technology and how to use the equipment effectively. Potential topics include understanding single frequency telemetry, equipment overview and representative deployments, detection performance and range limits, VEMCO User Environment (VUE) Software, VR2W positioning system (VPS), and future product directions. Participants will help explore problems regarding deployment methods, experimental design, identifying unknown codes, and data management, handling, and analysis.



JOURNAL HIGHLIGHTS

Transactions of the American Fisheries Society
Volume 143, Number 2, March 2014



Growth-Mediated Life History Traits of Steelhead Reveal Phenotypic Divergence and Plastic Response to Temperature. *Katy Doctor, Barry Berejikian, Jeffrey J. Hard, and Don VanDoornik*. 143:317–333.

Effectiveness of Instream Wood Treatments to Restore Stream Complexity and Winter Rearing Habitat for Juvenile Coho Salmon. *Kim K. Jones, Kara Anlauf-Dunn, Paul S. Jacobsen, Matt Strickland, Lora Tennant, and Sharon E. Tippery*. 143:334–345.

[Note] Effects of Surgically Implanting Radio Transmitters in Juvenile Largemouth Bass. *Brandon C. Thompson, Wesley Porak, and Micheal S. Allen*. 143:346–352.

Developing Standardized Methods for Sampling Freshwater Fishes with Multiple Gears: Effects of Sampling Order versus Sampling Method. *Mark S. Poesch*. 143:353–362.

[Note] Notes on the Reproductive Biology of Female Salmon Sharks in the Eastern North Pacific Ocean. *Christina L. Conrath, Cindy A. Tribuzio, and Kenneth J. Goldman*. 143:363–368.

Maternal Control over Offspring Life History in a Partially Anadromous Species, *Oncorhynchus mykiss*. *Barry A. Berejikian, Richard A. Bush, and Lance A. Campbell*. 143:369–379.

Growth and Survival of Sea Lampreys from Metamorphosis to Spawning in Lake Huron. *William D. Swink and Nicholas S. Johnson*. 143:380–386.

Using Cure Models for Analyzing the Influence of Pathogens on Salmon Survival. *R. Adam Ray, Russell W. Perry, Nicholas A. Som, and Jerri L. Bartholomew*. 143:387–398.

Proximate Composition and Energy Density of Stream-Maturing Adult Steelhead during Upstream Migration, Sexual Maturity, and Kelt Emigration. *Zachary L. Penney and Christine M. Moffitt*. 143:399–413.

[Note] Low Dose of the Anesthetic Propofol Does Not Induce Genotoxic or Mutagenic Effects in Nile Tilapia. *Graziela Valença-Silva, Mariana G. Braz, Rodrigo E. Barreto, Daisy M. F. Salvadori, and Gilson L. Volpato*. 143:414–419.

Changes in the Salmonine Community of Lake Michigan and Their Implications for Predator–Prey Balance. *Iyob Tsehaye, Michael L. Jones, Travis O. Brenden, James R. Bence, and Randall M. Claramunt*. 143:420–437.

Size- and Sex-Specific Capture and Harvest Selectivity of Walleyes from Tagging Studies. *Ransom A. Myers, Matthew W. Smith, John M. Hoenig, Neil Kmiecik, Mark A. Luehring, Melissa T. Drake, Patrick J. Schmalz, and Greg G. Sass*. 143:438–450.

Diel Reproductive Periodicity of Haddock in the Southwestern Gulf of Maine. *Katie A. Burchard, Francis Juanes, and Rodney A. Rountree*. 143:451–466.

[Forum] Fishing for Resilience. *Kevin L. Pope, Craig R. Allen, and David G. Angeler*. 143:467–478.

Advantages and Challenges of Genetic Stock Identification in Fish Stocks with Low Genetic Resolution. *H. Andres Araujo, John R. Candy, Terry D. Beacham, Bruce White, and Colin Wallace*. 143:479–488.

[Note] Examining the Effectiveness of Consumer Diet Sampling as a Nonnative Detection Tool in a Subtropical Estuary. *Ross E. Boucek and Jennifer S. Rehage*. 143:489–494.

Development of a Multimetric Index for Fish Assemblages in a Cold Tailwater in Tennessee. *Tomas J. Ivasauskas and Phillip W. Bettoli*. 143:495–507.

Comparison of Two Sampling Designs for Fish Assemblage Assessment in a Large River. *Ian A. Kiraly, Stephen M. Coghlan Jr., Joseph Zydlewski, and Daniel Hayes*. 143:508–518.

Movement and Growth of Juvenile Colorado Pikeminnows in the San Juan River, Colorado, New Mexico, and Utah. *Scott L. Durst and Nathan R. Franssen*. 143:519–527.

Feeding Habits Variability and Trophic Position of Dolphinfish in Waters South of the Baja California Peninsula, Mexico. *Y. E. Torres-Rojas, A. Hernández-Herrera, S. Ortega-García, and M. F. Soto-Jiménez*. 143:528–542.

[Note] Juvenile Rockfish Recruitment in Trinidad Bay, California. *Michelle K. Jones and Tim Mulligan*. 143:543–551.

Movements and Demography of Spawning American Shad in the Penobscot River, Maine, prior to Dam Removal. *Ann B. Grote, Michael M. Bailey, and Joseph D. Zydlewski*. 143:552–563.

NEW AFS MEMBERS

Erin Adams
Matthew Bach
Joel Bader
Cooper Barshinger
Lindsay Bellaw
M. Renee Bellinger
Brenda Ben James
Jordanna Black
Benjamin Bolam
Robert Bourdon
Caitlin Bradley
Shannon Brewer
Richard Brodeur
Nicholas Brown
Joshua Carpenter
Roger Choiniere
Frank Collier
Rachel Conway
Apryl Corey
Catherine Couillard
Joseph Coutu
Nicola Craig
Gregory Cravello
Andrew Cushing
Farrell Davis
Willem Dekker
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Sandra Diamond
Matthew DiMaggio
Carol Earnest
Mary Anne Evans
Kyle Flanery
Ed Fleming
Barbara Franano
Nick Franke
Chris Freiburger
Bryan Frueh
Marika Kirstin Gale
Katherine Gillies-Rector
Brynden Gorman
Michelle Gorrie
Natasha Gownaris
Joseph Greene
Christopher Gregg
Sylvia Gwozdz
Ernie Hain
Deborah Hart
Steven Hewett
Travis House
Chris Hunt
Carl Huntsberger
Lisa Izzo
Sylvia Jiménez Rosenberg
Doug Jones
Makoto Kawanago
Breeze Kelley
Karma Kissinger
Nicholas Kludt
Sarah LaMarr
Dominique Lapointe
Keely Ledbetter
Bongseon Lee
Jin Li
Tracey Loewen
Javier Lopez
Antonio Lopez
Jason Lorenz
Zachary Martin
Zak Maurer-Erickson
Lance McAvoy
Nicole McCasker
John McLaren
Natalie McNair
Cassie Mellon
Timothy Mihuc
Karina Mrakovcich
Andrew Muir
Matthew Neilson
Tatiana Neves
Leonardo Neves
Matthew Noland
Dana Ohman
John Onukwufor
Lisa Ozborn
Brittany Palm
Jennifer Pareti
Luke Poirier
Lucas Price
Carson Prichard
Timothy Pridmore
Danielle Quinn
Lana Ray
Justin Reuter
Daniel Ricard
Melissa Riley
Matthew Roberts
James Robinson
Erin Rodgers
Matthew Rouch
Zubaidah Sargent
Adam Schwindt
Anna Settineri
Matthew Shackelford
Gabriel Singer
Dan Sinopoli
Alexander Somers
Yiqing Song
Mark Sorel
Kimberly Sparks
James Spotila
David Stevenson
Margot Stiles
Eddie Stockert
Katherine Strickler
Matt Stuart
Anna Sturrock
Kenneth Sulak
Tyler Swanson
Steve Sylvester
Timothy Taylor
Bianca Terra
Katherine Thompson
Arturo Tripp Valdez
Bilikis Uneke
Aaron Urbanczyk
Katherine Velghe
Marcus Wharry
Julia Whidden
Kate Wilke
Chao Xiong
Shasha Zhao

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

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

More events listed at www.fisheries.org

DATE	EVENT	LOCATION	WEBSITE
June 7–11, 2014	World Aquaculture Adelaide 2014	Adelaide, South Australia	www.was.org
June 24–27, 2014	Iberian Congress of Ichthyology	Lisbon, Portugal	sibic.org/jornadas/2014/inicio_en.html
July 7–10, 2014	Fisheries Society of the British Isles Meeting & Call for Papers-Integrated Perspectives on Fish Stock Enhancement	Hull, England	fsbi.org.uk
July 30–August 3, 2014	American Society of Ichthyologists and Herpetologists Annual Conference	Chattanooga, TN	asih.org/meetings
August 3–7, 2014	International Congress on the Biology of Fish	Edinburgh, United Kingdom	icbf2014.sls.hw.ac.uk
August 16–20, 2014	AFS Annual Meeting 2014	Québec City, Canada	afs2014.org
August 16–20, 2014	38th Annual Larval Fish Conference (AFS Early Life History Section)	Québec City, Canada	larvalfishcon.org
August 31–September 4, 2014	AFS-FHS – International Symposium on Aquatic Animal Health (ISAAH)	Portland, OR	afs-fhs.org/meetings/meetings.php
September 15–19, 2014	ICES Annual Science Conference 2014	A Coruña, Spain	ices.dk/news-and-events/asc/ASC-2014/Pages/default.aspx
September 26–30, 2014	Aquatic Resources Education Association Conference	Traverse City, MI	www.areanet.org/conferences.htm
January 26–30, 2015	Global Inland Fisheries Conference	Rome, Italy	inlandfisheries.org
February 19–22, 2015	Aquaculture America 2015	New Orleans, LA	
May 26–30, 2015	World Aquaculture 2015	Jeju Island, Korea	
August 16–20, 2015	AFS Annual Meeting	Portland, OR	
February 22–26, 2016	Aquaculture 2016	Las Vegas, NV	
February 19–22, 2017	Aquaculture America 2017	San Antonio, TX	

Bringing Together Fish and Wildlife in 2017

Doug Austen, AFS Executive Director

AFS Executive Director Doug Austen can be contacted at: dausten@fisheries.org

A joint Fish and Wildlife meeting has never been done before at the national level, yet many of our Chapters and Divisions have become pretty good at hosting such events. Chapters frequently meet with their fisheries counterparts in neighboring states or with their wildlife colleagues in their own state. A great example is the Missouri Natural Resources Conference (www.mnrc.org), which has, for over a quarter of a century, been bringing together some combination of the Missouri Chapter of AFS, The Wildlife Society (TWS), the Society of American Foresters, and the Soil and Water Conservation Society. At the AFS Division level, our Northeast and Midwest members have been meeting jointly for many years under the auspices of their regional state fish and wildlife associations. Going back even farther, many of us actually obtained our degrees in university programs that were balanced fish and wildlife departments. Since the beginning we've recognized that fisheries and wildlife resources are intimately intertwined and are often best studied together. However, until recently, the two largest scientific societies have not been able to find a way to meet jointly. Certainly, there are obstacles to such an effort. The size and complexity of our meetings is a serious challenge for organizations of relatively modest means. Each society certainly also has a strong desire to maintain its own individuality. Bureaucracy also plays a role. We're on different meeting planning cycles and decision processes often don't align. Yet at our 2017 Annual Meeting, to be held in Tampa, we will be meeting jointly with TWS for the first time in the history of the societies. So what led to this rather substantial development?

...Second Vice President Margraf will have the pleasure of helping to develop, coordinate, and manage probably one of, if not the largest, most broad-ranging, complicated, and innovative fish and wildlife conferences ever to be held.

First of all, you should be aware that TWS is located in the office suite directly above AFS. Their executive director, Ken Williams, has his office directly above mine. Those of you who know Ken and his energetic conversational style will immediately realize that I am thereby made aware of his presence virtually every day. Office juxtaposition aside, one of the first conversations upon my starting at AFS was a long and fruitful lunch with Ken where we explored many options for TWS–AFS collaboration. Second, the selection of Tampa for the 2017 meeting, a location with clear Gulf of Mexico connections, opened up the immediate opportunity to highlight one of the largest ecological disasters and recovery efforts in our nation's history. Of particular significance is the broad, ecosystem approach of the restoration that, appropriately, recognizes the Gulf of Mexico as the sum of not just those immediate *Deepwater Horizon* insults but also all of landscape transformations and the resulting accumulated and transported impacts taking place throughout the largest river basin in North America. The only way to adequately discuss the science of the restoration of the Gulf and the Mississippi River basin is from the perspective of all natural resources with fish and wildlife being of obvious importance to our two societies. The Gulf provides the raison d'etre for a conference that focuses on the integration of wildlife and fisheries science in the broadest and most all-encompassing sense.

Third in the process of developing the 2017 meeting is the leadership of AFS. In our officer progression, the second vice president, Joe Margraf, has a major role in establishing the tenor of the 2017 meeting. This was, to a large degree, "his" meeting, where the theme, plenary speakers, and the overall focus of the event are established by Joe. One possible reaction to being presented with this type of event would be to negate the entire idea. Too problematic, the possible loss of identity, challenges of shared ownership, just too far out of the norm for AFS. In fact, just the opposite was the response. He embraced this approach and became a strong advocate for the joint event and made the motion to endorse the joint meeting to our Management Committee (which won unanimous support). As a result, Second Vice President Margraf will have the pleasure of helping to develop, coordinate, and manage probably one of, if not the largest, most broad-ranging, complicated, and innovative fish and wildlife conferences ever to be held.

Tampa will be a groundbreaking event; our wonderful hosts with the Florida chapters of AFS and TWS will begin working with the Bethesda office staff to start the process of figuring out the organizational structure of this event. New ground will be covered in joint ownership, branding, development of symposia, plenary speakers, sponsors, and all of the thousands of details that will demand attention. We've got over three years to put this together and will likely need every year, month, and day to make it a great success.

Regardless of how large an AFS conference is, all of our events are of the utmost importance and we are continually in the process of planning them. In just a couple of months we'll

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We need your help and that of your Section members

We currently have several policies needing revision.
(VISIT: fisheries.org/resource-policy-status)

We need knowledgable people from your Section to review one or more of the existing policies and help the RPC update them. These Policies summarize the Society's position on particular issues and they represent one of the principle mechanisms by which the Society advocates on behalf of fish, fisheries professionals, and aquatic resources. They are used to inform public policy (e.g., our climate change policy was used to comment on the National Climate Change Assessment), to inform regulatory authorities (e.g., our fish sedatives policy initiated a dialogue with the Food and Drug Administration about changes to the process of aquatic animal drug approvals), or to inform the public and our membership.

Please distribute this list to your Section members, along with a request to aid the RPC in updating our Policies. Interested members can contact Jesse Trushenski directly, and she will help them tackle the Policy of their choosing.

Again, thank you for your service, and we hope that you can help us. If you cannot do so, we would appreciate suggestions for persons who might.
Sincerely,

Jesse Trushenski
Chair, AFS Resource Policy Committee

Bob Hughes
AFS President

Donna Parrish
AFS President-elect

Hughes Visits JSFS Spring Meeting

AFS President Bob Hughes represented AFS at the Japanese Society for Fisheries Science (JSFS) meeting at Hakodate, Hokkaido. Hughes spoke at the JSFS Business Meeting and Banquet, and also presented a paper, "Recreational Fisheries in the USA: Economics, Management Strategies, and Ecological Threats."

"I was impressed by the formality, respectfulness, and brevity of the JSFS awards session," Hughes said. "I think that AFS can learn from the JSFS process."

Photos from Hakodate, the famous Hakodate Morning Market, and the JSFS meeting are available online at the AFS Flickr site: www.flickr.com/americanfisheriessociety.

A planning meeting for 2016 World Fisheries Congress in Busan, Korea, was also held. Earlier in the week, World Council of Fisheries Societies Vice President Shugo Watabe and Prof. Nam of the Korean Society of Fisheries and Aquatic Science met with Lee Convention Services, the professional conference organizers for the Congress. Watabe and Nam also toured the Busan Exhibition and Convention Center (BEXCO). The wing where most Congress activities will be held was just completed in 2012.

The theme for the 2016 Congress is "Challenges to Sustainable Fisheries and Safe Seafood" and major topics will include marine fisheries and fish biology, aquaculture, freshwater fisheries, biodiversity and management, and international cooperation and governance. The website is expected to be live this summer, and the Congress will take place 5–10 June 2016.

Situated on Korea's southern coast, Busan is a spectacular modern city of highrises, beaches, and mountains. BEXCO is located near the many hotels and restaurants of Gwangalli Beach and Haeundae Beach, sometimes called the Waikiki of Korea. From North America, Busan can be reached by air via Seoul or Tokyo, or by the KTX bullet train from Seoul.

Sake cask opening at JSFS Banquet.

Hughes at JSFS Banquet.

Gwangalli Beach.

Hughes shares a sake toast with Profs. Nam and Watabe.

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institutions—leading to an emphasis on narrow deliverables versus social or resource responsibilities, providing little time to think broadly, let alone think and act ethically (Bella 1992).

A scientific approach to obtaining knowledge and making decisions depends on the free and open exchange of information, including real-world observations, pattern analyses at multiple spatial and temporal scales, logic, and tactful disagreements. Especially in natural resource science, it is not the mythical, linear scientific method described in textbooks or envisioned in controlled laboratory settings, let alone groupthink (Kuhn 1962; Bernstein 1983; Bella 1992). Furthermore, science alone does not always speak for itself—especially when it conflicts with current scientific paradigms (Kuhn 1962; Soennichsen 2008), current government policies (Post and Hutchings 2013), iron triangles (Woody et al. 2010), or powerful industries (Aviv 2014). Because institutions tend to avoid unfavorable questions and focus on immediate issues, it is up to professional societies to review those questions and deliberate on long-term and large-scale concerns and policies in our meetings, committees, and journals (Bella 1992). Scientific and policy concerns that are ignored by institutions should be exposed and openly challenged by professional societies; if not, our professional societies will simply become another self-supporting institutional system (Bella 1992). The Society currently has several policy statements needing revision. They are foundation documents from which we advocate for fish, fisheries professionals, and aquatic resources; contribute to public and regulatory policy; and inform the public and our membership. If you would like to help with the revisions, contact me or Jesse Trushenski (saluski@siu.edu).

REFERENCES

American Fisheries Society. 1997. Standards of professional conduct. Available: fisheries.org/cert_standardsofprofessionalconduct (February 2014).

Aviv, R. 2014. Annals of science: a valuable reputation. The New Yorker 10 February:52–63.

Bella, D. A. 1992. Ethics and the credibility of applied science. Pages 19–32 *in* G. H. Reeves, D. L. Bottom, and M. H. Brookes, technical coordinators. Ethical questions for resource managers. U.S. Forest Service, General Technical Report PNW-GTR-288, Portland, Oregon.

Bernstein, R. S. 1983. Beyond objectivism and relativism. University of Pennsylvania Press, Philadelphia.

Bottom, D. L. 1992. Introduction. Pages 1–3 *in* G. H. Reeves, D. L. Bottom, and M. H. Brookes, technical coordinators. Ethical questions for resource managers. U.S. Forest Service, General Technical Report PNW-GTR-288, Portland, Oregon.

Boulding, K. 1970. The economics of the coming spaceship Earth. Pages 96–101 *in* G. deBell, editor. The environmental handbook. Ballentine, New York.

Hughes, R. M. 2014. Iron triangles and fisheries. Fisheries 39:147.

Karr, J. R. 2009. Natural: a benchmark, not a bias. Northwest Science 83:294–297.

Kuhn, T. S. 1962. The structure of scientific revolutions. University of Chicago Press, Chicago.

Leopold, A. 1947. A Sand County almanac. Oxford University Press, New York.

Lichatowich, J. 1992. Managing for sustainable fisheries: some social, economic, and ethical considerations. Pages 11–17 *in* G. H. Reeves, D. L. Bottom, and M. H. Brookes, technical coordinators. Ethical questions for resource managers. U.S. Forest Service, General Technical Report PNW-GTR-288, Portland, Oregon.

National Environmental Policy Act. 1969. Available: energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/Req-NEPA.pdf. (February 2014).

Oregon Revised Statutes. 2011. Food fish management policy, §506.109. Available: www.oregonlaws.org/ors/506.109. (February 2014).

Partridge, E. 1992. The moral uses of future generations. Pages 33–39 *in* G. H. Reeves, D. L. Bottom, and M. H. Brookes, technical coordinators. Ethical questions for resource managers. U.S. Forest Service, General Technical Report PNW-GTR-288, Portland, Oregon.

Pister, E. P. 1992. A pilgrim's progress from group a to group b. Pages 5–10 *in* G. H. Reeves, D. L. Bottom, and M. H. Brookes, technical coordinators. Ethical questions for resource managers. U.S. Forest Service, General Technical Report PNW-GTR-288, Portland, Oregon.

Post, J. A., and J. R. Hutchings. 2013. Gutting Canada's Fisheries Act: no fishery, no fish habitat protection. Fisheries 38:497–501.

Soennichsen, J. 2008. Bretz's flood: the remarkable story of a rebel geologist and the world's greatest flood. Sasquatch Books, Seattle, Washington.

Woody, C. A., R. M. Hughes, E. J. Wagner, T. P. Quinn, L. H. Roulsen, L. M. Martin, and K. Griswold. 2010. The U.S. General Mining Law of 1872: change is overdue. Fisheries 35:321–331.

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Board continues to contemplate the challenge of that commitment. You can contribute through many channels to help AFS make an informed decision.

There are roles for each of us in the advocacy realm. In a perfect world we'd have top-notch experts poised to address each issue, but not all experts are adept advocates. The most compelling stories about our most vexing issues will remain untold if we can't match the voice to the issue. If the silence continues we may suffer avoidable consequences.

It would be surreal if we could match member skill sets with our priorities, develop messages, and identify voices. If we decide to proceed, those crucial next steps will take time and must be strategic so that we move forward carefully but with conviction.

In my still-new new AFS, I'm reminded often that we could structure this debate in many ways. Regardless of the issue, we could start by reviewing the science, perhaps follow the AFS Governing Board's vision on priorities, seek to match our priorities with our charismatic strengths, script our primary messages, or focus on some other angle.

Regardless of where we start, and after months of rousing debate, I believe we will come to realize that advocacy is an appropriate role for AFS and its members. We will become comfortable working with the range of outlets, including but not limited to refereed journals and annual conferences. What John Boreman (2013) described as the "dynamic tension" between members on different sides of this issue will become a strength, as it was when I sought comments on earlier drafts of this column. While on that path I trust we'll grow more comfortable with advocacy and not view it as a secondary role. But my opinion needs to be challenged by the Society and its members. Only then will AFS come to a decision.

And not all advocates for fish need an advanced degree in ichthyology, resource economics, or any other profession represented in our Society. Just as a preeminent ecologist such as Rachel Carson may find comfort as an advocate, so might a talented journalist find a new mission in the fish world. Remember that there are two ingredients in my simple recipe for successful advocacy. Let's keep an open mind as we match the issues to the voice, all aimed at the benefits we select.

My point is to be open-minded, creative, and flexible. I sense the majority of AFS members and leaders are growing to embrace advocacy, but not everyone is in that same spot. Continued dialog will ensure that we make a reasoned decision that will strengthen our Society.

REFERENCE

Boreman, J. 2013. "President's Hook": On behalf of the fish. Fisheries 38(8):343. Available: http://www.tandfonline.com/doi/full/10.1080/03632415.2013.813484#.Ux8SZv2PKM8. (March 2014).

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harder to keep the converts quiet though. I may be relegated someday to making the casual GIS user (gulp) productive at a low cost. *(M. Riley, personal communication, January 24, 2014)*

While I don't expect QGIS or another open-source GIS project to supplant the industry giants any time soon, open-source GIS may prove to be an option for some of your workforce; particularly when facing some of the obstacles identified by Eder and Neely (2013) on the use of GIS at the agency level.

For additional information and links visit this installment of the Digital Revolution at: www.fishdata.org/blog/digital-revolution-gis-software.

REFERENCE

Eder, B. L., and B. C. Neely. 2013. Use of geographic information systems by fisheries management agencies. Fisheries 38:491–496.

Continued from page 218 (The Communication Stream)

you'll save yourself valuable time. For an excellent list of existing policies, browse through the Social Media Governance database (www.socialmediagovernance.com).

Provide examples. Though your communication policy will provide a number of valuable guidelines within which to operate, one of the most valuable things you can include are examples of do's and don'ts (especially taboo topics). Not only is this your opportunity to demonstrate the type of content you *want* shared, it helps others think about similar situations and how to deal them. Think of it as an exercise in mental calisthenics and preparation.

Provide education opportunities. Your new communication policy will not be able to provide guidance for every eventuality, nor would you want to—it would be overly lengthy and likely little referenced. Providing communication training gives staff the opportunity to engage and interact with others while helping prevent problems before they arise. Just remember, establishing ground rules is important, but creating an environment in which employees are encouraged and have the freedom to engage will protect the organization and do wonders for establishing a positive image (e.g., "branding").

Regularly review policies. The way we communicate has dramatically evolved and will invariably continue to change. There's no reason to let your communication policies stagnate, either. It is good business practice to regularly review and update your communication policy.

There are a number of other topics you may want to consider, including in your communication policy (e.g., identifying leadership, protecting privacy, accountability, disclosure, etc.), but these basic components will get you well on your way. Alternatively, if time is an absolutely critical commodity in extremely short supply, you can use the online Policy Tool for Social Media to get you started. This website runs you through a quick questionnaire (12 questions) and generates a policy (semi-)tailored to you or your organization. Regardless of which approach you take, a good communication policy will set the tone for engagement and interaction, help minimize potential problems before they arise, and better support the values central to your organization.

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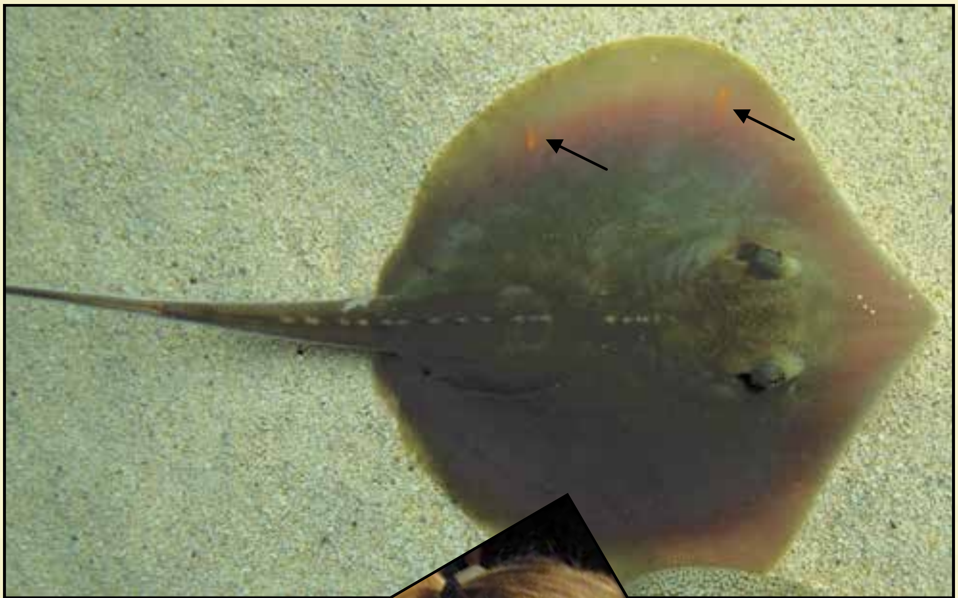
be in Québec City for what is increasingly looking to be an exceptional event—a beautiful city, with over 40 symposia and, at last count, over 1,600 abstracts and a wonderful host in our Canadian and Northeast members. Then, off to Portland in 2015 where we know we'll have a phenomenal event hosted by a group of seasoned meeting planners in a great northwest city. Finally, we'll meet in Kansas City in 2016 in the same location as this year's Midwest Fish and Wildlife Conference—a fantastic city, with excellent hotels and some of the best barbeque in the nation within walking distance.

Tracking Zoo Animals



Like so many zoos across the United States, the Point Defiance Zoo & Aquarium in Tacoma, WA has a mission to promote and conserve wild animals, both in their native habitats and at the zoo. While it is easy to recognize individual tigers or bears, it can be very difficult to recognize individual fish, amphibians, or reptiles. However, it is helpful to track which individuals or groups are receiving a certain food or treatment, how long they have been on display, which ones came from a particular place, or when they arrived. For zoo based breeding programs, it is crucial to be able to recognize the released animals so that their survival and contribution can be measured.

Visible Implant Elastomer (VIE) tags are injected beneath transparent or clear tissue so that they remain visible. The tags are available in a variety of colors which can be combined with tag location to make a coding scheme. The tags are easy to apply, have little effect on the host, and can be injected into even very small animals. For display animals, VIE is relatively inconspicuous compared to many other types of tags.

Biologists at Point Defiance selected VIE to identify individual stingrays. Each animal was given two tags and all tags were still present 7 months later. None of the stingrays reacted adversely to the handling or tagging, and some of them are reproducing in this very popular exhibit.

We have helped zoos and aquariums across the United States identify their collections of fish, frogs, lizards, mice and other animals. Please contact us if we can help with yours.

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