

# ESSAY: INTRODUCED SPECIES

A person wearing a red jacket, blue hat, and grey pants is standing in a stream, pouring fish from a white bucket into the water. The background shows a dense thicket of bare trees and branches.

## Are We Doing All We Can to Stem the Tide of Illegal Fish Stocking?

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### OVERVIEW

They've been called "bucket biologists" or "midnight managers" but these nicknames belie the ignorance and selfishness of individuals who engage in illegal stocking. Their actions are defeating multi-million dollar native fish recovery projects, damaging sustainable recreational fisheries worth billions of dollars, threatening native species with extinction, and diverting dwindling agency resources away from programs that benefit fishing and aquatic resources into expensive and often perpetual remediation programs. Illegal stocking is creating a growing burden on agencies and on society, and its impacts can be irreversible. The problem is global and yet there appears to be little collaboration across jurisdictions to seek solutions. We contend that the fisheries profession can and must do a better job of preventing illegal fish stocking through more strategic education programs, proactive regulatory policy, universally severe penalties, an international reward pool, and inter-jurisdictional collaboration.

### HOW BIG IS THIS PROBLEM?

The unauthorized, intentional release of aquatic animals to facilitate a fishery, which we refer to as "illegal stocking," is a global problem (e.g., Elvira and Almodovar 2001; Hickley and Chare 2004; Hardie et al. 2006). Within North America it appears to be more prominent in regions with fewer native gamefish species: west of the continental divide, and in the northern and northeastern regions of the continent. In Wyoming, 50% of the unauthorized introductions during the last three decades were deliberate, illegal introductions (Rahel 2004). Montana has documented more than 500 illegal introductions in almost 300 waters (Tipton 2007). Rapid range expansions of smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), rock bass (*Ambloplites rupestris*), and northern pike (*Esox lucius*) in Ontario (Jackson 2002; Vander Zanden et al. 2004); northern pike, yellow perch (*Perca flavescens*), and smallmouth bass in British Columbia (Runciman and Leaf 2008); and northern pike in southcentral Alaska (AFG 2009) are being facilitated by illegal stocking over regions with

thousands of rivers and lakes. In Maine, illegal introductions have established northern pike, largemouth bass, smallmouth bass, black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and green sunfish (*L. cyanellus*) in more than 150 lakes (Boucher 2007).

Many illicitly introduced populations have generated benefits from recreational fishing. However, in bypassing the regulatory process, each of these introductions has subjected the entire fishery and ecosystem to a degree of unnecessary risk from diseases, parasites, and invasive species that could have been accidentally introduced with the stocked fishes (Stewart 1991; Kerr et al. 2005). Further, some angler introductions have turned into tremendously expensive cleanup projects, as the following cases demonstrate.

### LAKE DAVIS, CALIFORNIA

Lake Davis is a 1,629 ha reservoir in northeastern California. Illegally introduced northern pike were discovered in 1994 and were deemed a serious threat to a variety of native species downstream, including many state- and federally-listed species (CFG 2007). The reservoir was treated with rotenone to eradicate northern pike in 1997 at a cost of \$16 million (CFG 2007). Northern pike reappeared in 1999, either due to an unsuccessful treatment or another illegal introduction. Attempts to control and contain the population were unsuccessful and live northern pike were intercepted in possession of anglers stopped at check stations as they were leaving the reservoir. In fall 2007, the reservoir was treated with rotenone again, at a cost of more than \$17 million (Keith 2007). It remains to be seen if this second attempt at eradicating northern pike was successful, and if anglers will reintroduce the species in the future.

### YELLOWSTONE LAKE, WYOMING

Yellowstone Lake, in Yellowstone National Park, is one of the largest and most pristine inland lakes in the United States, and it was home to 90% of the remaining Yellowstone cutthroat trout

(*Oncorhynchus clarki bowleri*; Gresswell 1995). Illegally introduced lake trout (*Salvelinus namaycush*) were discovered in the lake in 1994 (Kaeding et al. 1996). Studies predicted that left unchecked, predation by lake trout could result in a severe decline in the cutthroat population (Ruzycki et al. 2003) with a 30-year economic impact on park fisheries of about \$900 million (Varley and Schullery 1995; adjusted for inflation). Consequently, the National Park Service (NPS) implemented a vigorous lake trout suppression program at a cost of about \$300,000 per year (P. Bigelow, NPS, pers. comm.).

The preceding examples illustrate the enormous biological and economic impacts that can result from an isolated illegal stocking event that is confined to a single body of water. More frightening by far is illegal stocking occurring at the landscape scale, where anglers are introducing nonnative fish throughout an entire river basin. These actions are frustrating agencies' best efforts to balance sustainable recreational fisheries and native fish conservation, and jeopardizing countless evolutionarily significant units of endangered, threatened, and special concern species.

### UPPER COLORADO RIVER BASIN

The Upper Colorado River Basin covers a 284,000 km<sup>2</sup> area of Arizona, Colorado, New Mexico, Utah, and Wyoming above Glen Canyon Dam. Only 14 species of fish are native to this region, 57% are endemic, and 5 are federally listed as endangered (Valdez and Muth 2005). Managed fisheries typically emphasize nonnative salmonids because of their limited impact on native species. Anglers unsatisfied with these have illegally established more than 46 populations of cool- and warmwater species in at least 22 reservoirs and the endangered fish recovery program is spending \$1million/y controlling these species in critical habitat. These illegal introductions also threaten the relatively innocuous nonnative fish populations in reservoirs that have sustained valuable recreational fisheries. Further, illegal stocking is diminishing the recovery potential of recent fish passageways constructed for native fish (Figure 1). Water diversion structures constructed in the early

**Figure 1.** The Price-Stubb Diversion Dam fish passage on the Colorado River near Grand Junction, Colorado, was completed in 2008. Removal of this barrier to fish migration provided endangered fish access to an additional 84 km (52 miles) of critical habitat that had been blocked since 1911.



U.S. FISH AND WILDLIFE SERVICE.

1900s created barriers to fish migration that prevented both native and nonnative fish from accessing large reaches of critical habitat of the Colorado and Gunnison rivers. The endangered fish recovery program has built selective fish passageways (total cost \$30 million, Chuck McAda, U.S. Fish and Wildlife Service, pers. comm.) to restore native fish access to this habitat. Unfortunately, illegally stocked northern pike, smallmouth bass, walleye (*Sander vitreus*), and other species in reservoirs above the barriers have the potential to invade the upstream reaches and defeat the purposes and multimillion dollar expenditures of these fish ladders.

Evaluating the full scope of illegal stocking is difficult due its cryptic and diffuse nature and the impracticality of routine monitoring of spatially dispersed ecosystems. What is clear is that this simple act can have catastrophic ecological impacts and generate enormous economic losses and remediation costs that may continue in perpetuity. While the initial release that establishes a species in a new water body can be an isolated event, the new population can become a chronic source of dispersants that subsequently invade other locations across the landscape by natural or facilitated dispersal (Havel et al. 2005; Rahel 2007).

## HOW DID WE GET HERE?

Regrettably, we see illegal stocking as a problem born out of our own profession's historical behavior, and perpetuated by ineffective or conflicting messages to the public regarding authorized and unauthorized fish stocking policy.

### 1. *Do as we say, not as we do.*

Unauthorized stocking may be partly a legacy of our profession's promiscuous fish stocking past (Li and Moyle 1999) and our present conduct. Many popular recreational fisheries in North America and elsewhere are directed at introduced fishes, some sustained by authorized stocking. Agency transfers of fishes outside their native range and mixing of locally adapted genetic stocks continue today in spite of growing evidence that these practices can have detrimental ecological and genetic impacts (Cross 2000; Goldberg et al. 2005). Agencies continue to promote fish culture and stocking (e.g., hatchery tours, stocking tallies in the media) because it is an expedient way to demonstrate apparent benefits flowing from the license dollar. However, in doing so, we may have instilled the notion among anglers that fisheries can be created or remedied just by stocking fish (Meffe 1992; Arlinghaus and Mehner 2005; Arlinghaus 2006). Cooperative agency-angling club fish rearing and stocking programs further reinforce this perspective and break down the traditional barrier that rested stocking authority in the hands of agencies alone. As professionals, we should recognize that we may have contributed to the problem by unintentionally indoctrinating anglers with potentially unrealistic and ecologically unsustainable attitudes about stocking (Arlinghaus and Mehner 2005).

### 2. *Ineffective information and education programs.*

Noncompliance with stocking regulations may be partly due to information and education programs that are not reaching the audiences or are not convincing and persuasive. Some anglers may be unaware that transporting and releasing fish in another body of water is illegal, or they may simply not appreciate the severity of potential impacts. Management organizations appear to be acting independently, using variations on the same basic strategy: prohibit unauthorized stocking

and attempt to inform anglers and other stakeholders about the harm it can do. However, the seriousness with which agencies appear to be dealing with the issue differs greatly among jurisdictions. Effort devoted to information and education programs ranges from simple statements that transplanting fish is illegal to elaborate web sites with videos and other resources to download (e.g., AFG 2009). If agencies do a poor job of communicating the negative consequences of illegal stocking angler attitudes will change slowly, particularly when there can be obvious fishery benefits associated with a successful introduction.

Some anglers are aware of the ecological issues and the rationale for stocking regulations but choose to violate the rules in spite of that knowledge. Information and education programs have not failed to reach these individuals, but we have failed to compel appropriate behavior in them by other means, for example by deterrents such as penalties.

### 3. *Inadequate deterrents.*

Nearly every U.S. state and Canadian province/territory has had laws regulating the release of non-native fishes since at least 1974 (Courtenay and Robins 1975; Courtenay 1995). Is lack of enforcement the paramount problem? We do not think so. Enforcement clearly has a role but should not be viewed as a practical and sufficient solution in the future. We believe we must find other ways of discouraging people from engaging in illegal stocking and stiff penalties for the act are one way to do that. Based on a survey of agency fisheries and law enforcement personnel, penalties for unauthorized stocking, vary greatly. Canada had the most severe penalties: illegal fish stocking can fall under the jurisdiction of the federal Fisheries Act which can impose fines of up to \$100,000 and a year in jail for a first offense. Among the 12 U.S. states with some territory west of the Continental Divide, Colorado had the most lenient penalty: a \$68 fine with no jail time and no loss of fishing privileges, and Alaska had the harshest maximum penalties with a \$10,000 fine and a year in jail with loss of fishing privileges. The average maximum fine across all 12 states was \$2,756. It is likely that the minor penalties in place for illegally stocking fish in some jurisdictions are contributing to misperceptions of the seriousness of the problem among anglers but also within agencies and the legal system.

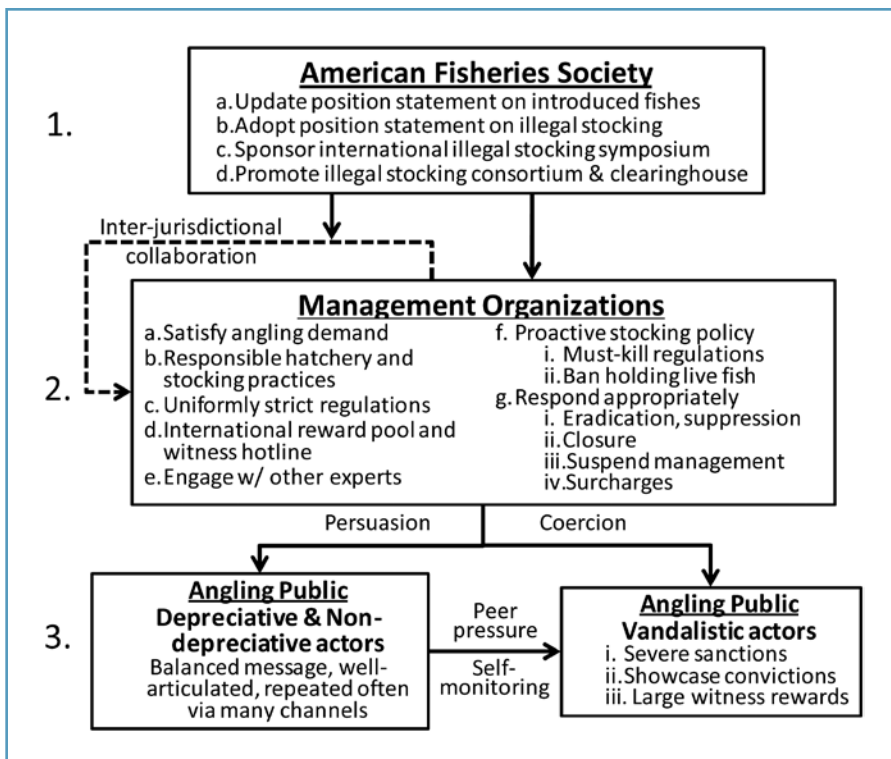
### 4. *Inappropriate responses.*

The way in which an agency responds to an illegal stocking event is an important signal to the public that may shape their attitudes about the practice. In the past, unauthorized introductions probably met with little concern and may even have been ultimately welcomed by managers if the species contributed to a net increase in fishing quality. Even today, exasperated management agencies may simply throw up their hands and concede when anglers introduce nonnative fishes. In Colorado, anglers illegally established northern pike fisheries in several reservoirs west of the Continental Divide, where stocking non-salmonid sport fish is restricted due to concerns about endangered fish. By failing to respond vigorously to these illegal introductions, and in one case even implementing a special size limit for the illegal pike, the agency tacitly condoned and rewarded the behavior, generated an angling clientele and a demand for the prohibited species elsewhere in the region, and made future efforts to contain the spread of northern pike and other illegally stocked species much more challenging.

## SOME SUGGESTIONS FOR PROGRESS

We believe there are many things that can be done to help stem the tide of illegal fish introductions, focusing attention at three levels (Figure 2): (1) the fisheries profession, (2) management agency policy and actions, and (3) the angling public.

**Figure 2.** A framework for progress on the problem of illegal stocking focusing changes at three levels: (1) the fisheries profession, (2) management organizations, and (3) the angling public. The fisheries profession can facilitate collaboration among management organizations (dashed feedback arrow).



### 1. Changes within the fisheries profession.

**Adopt position statements.** Professional organizations' position statements help society by defining the current state of the science and expert opinion on an issue. Policymakers should be able to turn to the AFS for such insights when getting tough on illegal stocking requires agencies to adopt regulations that may be unpopular with some anglers (e.g., prohibitions on live fish as bait, or holding live fish). As professionals, we should support the AFS Introduced Fishes Section in updating the Society's "Policy Statement on Introduced Aquatic Species." The Society also has the opportunity to consider a resolution specifically addressing illegal stocking, put forth by Colorado-Wyoming Chapter for adoption by the parent Society.

**Inter-jurisdictional collaboration.** Agencies could all do a better job of combating illegal stocking if they could learn from each others' experience. Further, by pooling resources the group could acquire educational materials of a caliber unattainable by any individual jurisdiction. We invite you to contribute to our new website <http://stopstocking.cowyafs.org/>, which can serve as a virtual clearinghouse for gathering illegal stocking information, educating the public, soliciting witness information, showcasing convictions, and sharing policy documents and education materials among agencies. As a professional organization, AFS is in a position to facilitate

collaboration that individual states and provinces cannot, by appealing to national or international bodies for resources to help jurisdictions work together.

**Symposium and workshop.** The AFS could facilitate inter-jurisdictional collaboration by sponsoring an international symposium and workshop to bring representatives from management institutions, law enforcement, and other groups together to share experience and ideas and to establish the means for states and provinces to continue to work together on the illegal stocking issue. Illegal stocking of sport fish is recognized as a problem throughout the developed world (Elvira and Almodovar 2001; Hickley and Chare 2004; Hardie et al. 2006) and fish stocking experts from other continents (e.g., Cowx 1998) have tremendous experience and knowledge that could be shared in such a venue.

**International reward pool and witness hotline.** Among the 15 western states and provinces the typical maximum reward being offered was about \$2,000, which doesn't convey the seriousness of the crime and may not motivate an individual to turn in a fellow angler. There would be many benefits of states, provinces, and territories pooling reward resources, possibly administered by a non-profit fishing organization, including international exposure for the issue, endorsement and promotion of the cause by a non-regulatory body, superior fund raising capabilities, and combined resources that could easily increase rewards offered to \$50,000 per conviction. Further, centralization would enable the creation of a toll-free witness hotline (e.g., 1-800-FISH-COP), so a single telephone number could be displayed all over North America to report illegal fish stocking.

### 2. Changes in management organizations.

Agencies can do a number of things to eliminate the motivation and rewards particular people receive from illegal stocking, and to convey the message that illegal stocking will not be tolerated.

**Satisfy angling demand responsibly.** When possible, illegal stocking may be minimized by understanding angler desires and satisfying the demand for alternative angling opportunities with more sustainable options. These might include improving existing fisheries through habitat management, more effective harvest regulations, or improved stocking protocols for existing species. In some cases, use of sterile fish might satisfy the desire for a fish that is not common locally, if compatible with widely accepted stocking policies. However, we need to send the message that stocking is only appropriate when scientifically justified and ecologically sound, and management authorities should hold themselves to this standard. Keeping our own house in order by demonstrating good stewardship is prerequisite to requiring responsible behavior from anglers.

**Uniformly strict regulations.** Highly developed Internet-based social networks allow anglers to exchange information about fishing

and fishing regulations anywhere. Inconsistency among jurisdictions in regulations and penalties pertaining to unauthorized stocking creates the impression that the practice is not universally contemptible, may give stakeholders a pointless bone of contention, and creates unequal and inequitable control of risks of introductions among bordering jurisdictions. As Courtenay and Robins (1975) suggested, a model law with consistent format, rationale, and penalties could be developed, and then tailored as necessary for implementation in each jurisdiction.

**Proactive policies: “must kill,” live fish bans.** Enacting “must kill” regulations in advance for prohibited species demonstrates agency resolve, and can reduce the motivation to stock illegally. Although enacted after the fact, mandatory kill regulations were established for northern pike at Lake Davis (CFG 2007), lake trout at Yellowstone Lake (Koel et al. 2005), and illegally stocked burbot (*Lota lota*) in Utah (UDWR 2009). Banning the possession of live fish, either as bait or in the creel, or simply banning the transport of water, might be considered draconian measures by some, but there are many benefits. Such bans make it much less likely for anglers to move fish from one water body to another, they make law enforcement much simpler, and there would be a reduced likelihood of transmission of invasive aquatic organisms or potentially devastating diseases.

**Respond appropriately: closures and surcharges.** Agencies can communicate the message that illegal stocking is intolerable by closing illegally stocked waters to fishing. Such an action denies benefits for the perpetrator and may result in peer pressure against future violations. A recent example of such forthright actions occurred in British Columbia where officials closed eight lakes to fishing in June 2007 after discovering that the lakes had been illegally stocked with yellow perch (Maricle 2007). In addition to clearly demonstrating to anglers the seriousness of the issue, this action may be required to “quarantine” invasive species and give agencies time to attempt to eradicate them before anglers have the opportunity to move them to other waters. Economic measures may also be helpful. For example, a surcharge for fishing on illegally stocked waters would raise funds to offset mitigation costs but more importantly may generate ill will in the local angling community toward the perpetrator that could dissuade that person and others from engaging in illegal stocking in the future.

### 3. Changes within the angling public.

We believe there are fundamentally two types of people engaged in illegal stocking, requiring different management approaches. The first type, “depreciative” actors (Knopf and Dustin 1992), are probably ignorant of the law and the detrimental effects of unauthorized stocking. They should respond to well-grounded and balanced arguments about the negative effects of illegal stocking. Involving highly respected professional anglers in communication campaigns could enhance credibility and message delivery. The message should be repeated over as many channels as possible, e.g., face-to-face, seminars, angling clubs, magazine articles, newspaper, radio, TV, and Internet. The message must be based on sound knowledge, convincing reasoning, and avoid appeals strictly on moral grounds. A balanced message including impacts to ecosystems, recreational fisheries, economies, and the image of recreational fishing as a pastime is most likely to be most convincing.

The second type, “vandalistic” actors (Knopf and Dustin 1992), stock fish illegally despite knowledge of the law and potential negative effects. Harsh and highly visible sanctions, witness rewards, peer pressure, and enforcement are strategies to coerce vandalistic actors (Ajzen 1992). Sanctions for illegal stocking should be severe, commensurate

with the severity of potential ecological and socioeconomic impacts (Ostrom 2005). Illegal stocking can have vastly greater ecological impacts than harvesting a big game animal illegally, and yet in some jurisdictions the fine for the latter is orders of magnitude higher than the fine for stocking fish without a permit. Why shouldn't all jurisdictions follow Canada's example and increase the maximum penalty for illegal stocking to \$100,000? Can anyone deny that the introduction of a nuisance aquatic species would cause at least this amount of damage? Revocation of fishing privileges denies perpetrators the ability the reap benefits from their actions; the maximum ought to be permanent revocation, and it should be recognized by all jurisdictions continent-wide. For harsh penalties to be fair and effective as deterrents the public must be aware of them so agencies must couple rule changes with effective outreach.

## CONCLUSIONS AND OUTLOOK

It would be easy for the fisheries profession to shirk responsibility for this problem by simply declaring a need for more education and enforcement. We believe it will take more than posters and check points to make progress with this issue, and we think we have offered some substantive suggestions. We also see the need to broaden the search for solutions, both conceptually and geographically. As fisheries professionals most of us have limited training in the “human dimensions” of our field (Fulton and Adelman 2003). We are thus ill-prepared to understand the varied values and motivations of our clientele, effectively educate and motivate policy makers, and grasp the realities of law enforcement and criminal justice. To be more effective in preventing illegal stocking now and in the future, we will need to engage with experts from other fields including sociology, psychology, law, environmental education, political sciences, marketing and communication, and reach out to our colleagues worldwide with the common goal of closing a major and preventable pathway of aquatic invasions. The task is clear, the responsibility rests with us and the time to start is now.

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