Conflicts between Native Fish and Nonnative Sport Fish Management in the Southwestern United States

The ubiquitous presence of nonnative fishes, both sport and nongame, within waters of the southwestern United States is the foremost factor preventing immediate conservation and recovery of imperiled native fishes. We present evidence that the two fishery types cannot be co-managed in sympathy if natives are to persist. A dual responsibility of federal and state fish and wildlife agencies to manage both fishery types creates internal conflicts that typically are resolved in favor of nonnative sport fisheries, despite existence of the Endangered Species Act. We advocate designation of watersheds to be managed exclusively for one fishery type or the other, and implementation of an aggressive program to eliminate nonnatives in native-designated waters and protect against their reinvasion. To mitigate institutional conflicts, agency infrastructures should be segregated to promote independent management of native fisheries and introduced sport fisheries. This approach can fulfill mandates of both the Endangered Species Act and the 1996 Fish and Wildlife Service policy on recreational fishing.

Robert W. Clarkson
Paul C. Marsh
Sally E. Stefferud
Jerome A. Stefferud

Clarkson is a fishery biologist in Phoenix, Arizona. Marsh is a research professor at Arizona State University, Tempe and can be reached at fish.dr@asu.edu. S. Stefferud and J. Stefferud are retired fishery biologists in Phoenix.

introduced fish
perspective

Introduction

Native freshwater ichthyofaunas of the southwestern United States have declined and their status continues to deteriorate; the entire fauna is imperiled (Miller 1961; Minckley and Deacon 1968; Fagan et al. in press). Losses are due to development of water supplies, physical habitat alteration that favors nonnative fishes, and introduction and establishment of nonnative fishes and other aquatic biota (Fradkin 1981; Minckley and Deacon 1991). Early declines were principally a result of habitat destruction and alteration. However, in the past few decades it has become apparent that presence of nonnative fishes precludes or negates benefits from habitat protection and restoration (Mueller 2005, this issue). Contamination by nonnative fishes now is the most consequential factor preventing sustenance and recovery of imperiled native fishes in the Southwest (Meffe 1985; Minckley 1991; Marsh and Pacey 2005), and perhaps globally (Cambray 2003). No amount of habitat restoration can successfully advance biological recovery unless preceded or accompanied by elimination of nonnatives (Marsh and Pacey 2005; Mueller 2005, this issue).

Most of the 50+ nonnative fishes established in the region were introduced as sport species, as forage for sport fish, or as bait (Fuller et al. 1999). Although the rate of introductions of novel, nonnative sport species has declined (Rinne and Janisch 1995; Dill and Cordone 1997), both federal and state agencies continue to actively stock, manage, and promote nonnative recreational fisheries. States derive monetary benefit from these programs via license sales and federal subsidies, and federal excise taxes help support the U.S. Fish and Wildlife Service’s (USFWS) sport fish programs (e.g., Federal Aid in Sport Fish Restoration). Primary political support for state game and fish agencies comes from the hunting and recreational fishing public. Yet these same agencies are charged with protection and recovery of native fishes that are directly affected by introduced sport fish species.

We examine the conflicts that arise from the dual responsibilities of USFWS and state fish and game agencies to conserve and recover threatened and endangered native fishes and stock, and manage nonnative sport fisheries. Our experience is in the Southwest, but the issue is relevant to all states that promote nonnative sport fisheries. We define the scope of these management conflicts and show how they result in the neglect of nongame native fishes, an assertion supported by continuing declines of these species even since passage of the Endangered Species Act (ESA) and completion of recovery plans under that act. We present our thoughts as to how to minimize or isolate these conflicts through both institutional and on-the-ground changes in management.

The Problem with Nonnatives

Nonnative fish are now nearly everywhere in the region (Fuller et al. 1999), and where habitable perennial habitats remain, prevent stabilization and recovery of most imperiled native species (Moyle et al. 1986; Minckley 1991; Marsh and Pacey 2005). Effects of nonnative
Fishes on natives result from interactions among life histories, behaviors, and habitat use. The introduced fauna is comprised of mostly piscivores, while native species are mostly generalists (Pacey and Marsh 1998). Native fishes of the region are considered predator-naive (Johnson et al. 1993; Johnson and Hines 1999), and lack behavioral mechanisms to cope with or avoid the array of predators introduced into their habitats. In the Colorado River basin, for example, native warmwater fishes co-evolved with only a single piscivore (Colorado pikeminnow *Ptychocheilus lucius*), while most introduced fishes evolved within drainages containing many predators (e.g., Mississippi River basin).

Introduced fishes typically are phylogenetically advanced taxa that possess sophisticated life history and behavioral traits that allow them to persist within intensely competitive, saturated communities (Minckley and Rinne 1991; Douglas et al. 1994). For example, most nonnative fishes afford some degree of active protection to their young via nest building or other behavioral traits, while native forms are mostly broadcast spawners with no parental care, and generally do not possess such sophistication of life history and behavior (Pacey and Marsh 1998).

One result of these differences is that native fishes typically fail to recruit young in the presence of nonnatives (Marsh and Minckley 1989; Pacey and Marsh 1998; Dudley and Matter 2000). Predation on natives by introduced forms during early life stages is the most likely mechanism resulting in failure of natives, but other avenues also contribute (Tyus and Saunders 2000). Nonnative fishes such as green sunfish (*Lepomis cyanellus*), western mosquitofish (*Gambusia affinis*), and red shiner (*Cyprinella lutrensis*) are ubiquitous even in shallow, near-shore habitats used as nursery areas by larval native fishes, where they consume or harass natives into decline or extirpation (Meffe 1985; Ruppert et al. 1993; Osmundson 2003).

In addition, nonnatives may be released from much of their co-evolved parasite and disease load due to over-dispersion of parasite communities and small founding populations of introduced fishes (Torchin et al. 2001; Stockwell and Leberg 2002). At the same time, novel introduced parasites and diseases that are not co-evolved may differentially affect native fishes (Stockwell and Leberg 2002).

Only in rare instances have natives persisted among introduced forms over a long history, and by long we mean only several decades (Stefferd and Stefferud 1995; Bryan et al. 2000). However, these situations are largely unstudied, and proposed mechanisms that might allow coexistence are speculative. Disturbance, especially flash flooding that is common to the Southwest, has been suggested as a mechanism that in some cases may allow persistence of native fishes when they are sympatric with introduced species (Johns 1963; Minckley and Sommerfeld 1979; Minckley and Meffe 1987). However, the near-ubiquity of nonnative fishes across the region ensures that the impacts of predation, competition, or parasitism are ever-present factors limiting successful completion of native fish life cycles. The fact is, where nonnatives become established, natives invariably wane or disappear. Given the present state of knowledge, our conclusion is that native and nonnative fishes must be segregated if the former are to survive.

**Intra-Agency Conflicts**

The dual management responsibility of federal and state fish and wildlife agencies for both threatened and endangered native fishes and nonnative sport fisheries has existed since before the 1973 enactment of the ESA. However, before the 1970s little conflict was apparent because neither state nor federal agencies invested much thought or effort in nongame native fish, and information on native fish declines alarmed only a few specialists (Minckley and Deacon 1991). At least one state characterized itself as "insensitive to native fish management" (Rinne and Janisch 1995:403).

Increased ESA listings of southwestern native fishes combined with poor recovery success highlighted the conflict between nonnative sport and native fish management (Cain 1993). Pressure to conduct ESA Section 7 consultation on federal and federally-funded state nonnative fish stocking programs increased awareness of the conflict,
and within USFWS there were disagreements over allocation of federal fish hatchery resources between sport and native fishes (GAO 2000); neither resulted in resolution. The USFWS was directly confronted with the conflict in 1995 when an Executive Order directed federal agencies to “improve the quality, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreational fishing opportunities” (Federal Register 60:30769).

Working cooperatively with the Sport Fishing and Boating Partnership Council, an advisory panel to the Secretary of Interior, the USFWS and National Marine Fisheries Service formulated a policy to implement the Executive Order (Lassuy et al. 1999). Public comment on the draft policy expressed concern that elevating considerations for sport fisheries would dilute conservation efforts for threatened or endangered fishes. The 1996 final policy entitled “Conserving Species Listed or Proposed for Listing under the Endangered Species Act while Providing and Enhancing Recreational Fisheries” (Federal Register 61:27978) acknowledged the conflict between recovery of listed fishes and promotion of recreational fisheries, but lacked substantive guidance as to how to ameliorate or eliminate the problem. The policy’s primary focus was to resolve conflicts through increased public education and increased involvement in native fish recovery programs for federal agencies, state and tribal governments, conservation organizations, and recreational fisheries stakeholders. Emphasis was placed on “eliminating unnecessary recovery based restrictions affecting recreational fisheries.” The policy did not direct cessation of nonnative fish stocking into waters with federally-listed or proposed native fishes, but instead called for evaluation of potential impacts of such stockings based on biological information and socioeconomic objectives including recreational fisheries. However, it appears the policy has been generally ignored by management agencies in the Southwest.

The USFWS has little dedicated funding for implementing coordinated recovery programs and only a small proportion of that amount is allocated to nongame fishes (GAO 2002; USFWS 2003). State funding ratios are similar (Gabelhouse 2005). Moreover, most of those monies are spent on high “public appeal” species and those approaching recovery (GAO 1988). Piecemeal conservation is sometimes achieved when federal actions are mitigated through Section 7 ESA consultations. In addition, USFWS delegates much of its recovery authority and a portion of its funding to the states through Section 6 of the ESA, and in fact has begun executing formal memoranda of agreement (MOA) with states to further increase their role in implementing ESA (e.g., USFWS and AZGFD 2002).

In concept, this relationship should foster recovery efforts for listed species. In reality, because states have no mandated authorities to implement the ESA except as delegated by (and largely funded by) the USFWS, and because most southwestern states do not have provisions for citizen lawsuits in behalf of wildlife, they are seemingly immune to legal pressures from groups that seek more proactive recovery efforts. The dilution of federal authority and accountability through such MOAs may actually weaken recovery efforts for listed fishes, not strengthen them.

Whether one agrees or disagrees with these assertions, the fact remains that regional native fish faunas continue to decline (Minckley and Rinne 1991; Fagan et al. 2002), and recovery actions that have been undertaken or proposed for threatened or endangered fish have been ineffective, or worse, neglected and avoided. It is inarguable that not enough is being done to stem continuing losses. We believe this is mostly due to internecine conflicts between nonnative sport and native fishery interests, and we have observed that these conflicts are usually resolved in favor of the sport fishery.

The only exceptions seem to be where threatened or endangered fishes happen also to be sport species (e.g., trouts), or where habitat conservation plans have been established that provide ambiguous assurances to development and sport fishing interests. Southwestern states have implemented programs for endemic trouts that included removal of established nonnative trout fisheries (Rinne and Turner 1991; Propst et al. 1992; Young and Harig 2001). In many cases, nonnatives have been removed from entire watersheds and replaced with indigenous trouts, usually protected against recontamination by natural or artificial barriers. These are highly commendable programs that need to be mimicked with nongame native species, but similar programs for such species are conspicuously rare.

**Recommendations to Minimize the Conflict**

In most cases, we know what is needed to begin the recovery process for southwestern native fishes, which simply is to segregate natives and nonnatives. The techniques to do so for the most part are technically and economically feasible. Significant recovery of many southwestern native fishes can be accomplished with reasonable compromise by sport fishing interests. Once waters are designated for exclusive management of one fishery type or the other, full devotion of resources to both will better enable accomplishment of management goals. We argue that by
recovering threatened and endangered fishes now, long-term costs for conservation, sport-fishing interests, and the nation and its people will be greatly lessened.

**Biological Conflicts**

The exemplary success to date with recovery programs for native trouts in the Southwest has been completely reliant upon the premise that native trouts cannot persist in the presence of nonnative, especially congeneric, trouts. Rinne and Janisch (1995) described use of segregated management to allow for recovery of native trouts while maintaining sportfishing opportunities for nonnative trouts. It is routine in high elevation, cold water streams to identify native trout recovery reaches, erect physical barriers to prevent contamination by nonnatives, chemically or otherwise remove nonnatives above the barriers, and repatriate native trouts (Finlayson et al. 2005). The same can be done for many native warmwater species.

Warmwater fish communities of most major southwestern rivers are predominated by nonnative species and native kinds are severely depleted or gone (Tyus et al. 1982; Minckley 1991; Mueller and Marsh 2002). We do not at this time see a practical approach to completely reclaiming these systems for native fish recovery (Dawson and Kolar 2003), and expect the nonnative fishes and the minor recreational use they support will continue. However, this does not minimize the value of major rivers to native fish recovery, for example, where active programs are in place to enhance imperiled species and reduce the abundance of nonnatives, and thereby reduce their impacts (Tyus and Saunders 2000), or where off-channel habitats can be constructed and managed exclusively for natives (Minckley et al. 2003).

Populations of introduced species already occupy reservoirs and the few natural lakes in the region, and these habitats support substantial recreational fisheries. It is impractical, by any measure, to eliminate these fishes from these lentic habitats. We envision these systems will continue into the foreseeable future to harbor nonnative fish assemblages and support sport fisheries, and mostly will not be amenable to management in behalf of native fishes (but see Mueller 1995 for a notable exception).

Medium and small warmwater streams and stream systems, however, represent valuable native fish habitat but are of little value as recreational fisheries. In addition to native species that persist, many of these streams are occupied only by smaller-bodied, nonnative centrarchids, ictalurids, and cyprinids and not the large individuals typically sought by sport fishers. In addition, they often are remote and difficult to access, and some are isolated from other waters by typically dry reaches or in some instances by natural or other barriers. Finally, because of their relatively small size and seasonal low flows, many of these systems appear amenable to removal or substantial reduction of nonnative fishes. We envision these places as potential candidates for recovery of most imperiled native species. These streams provide opportunities where the biological conflicts can be resolved and where the institutional conflicts can be minimized.

Most stream dwelling native fishes of the American Southwest were historically widespread in distribution, and local populations were interconnected through time, affording opportunity for individuals to move freely among streams. While the historical condition will not again exist in the foreseeable future, a recovery strategy that incorporates the concept of connectedness is critical to long-term conservation of these fishes. The geographic scope of this strategy needs to include interconnected drainage networks of tens to hundreds of kilometers of live streams embedded in watersheds of hundreds to thousands of square kilometers. It is not enough to segregate the natives within short, isolated reaches because such populations cannot exchange genetic material with their conspecifics, unless by active human management, and thus can suffer undesirable effects of inbreeding, genetic bottlenecks, or extirpation that often are associated with small populations (Ballou et al. 1995). Connectedness is also important in avoiding demographic and environmental events that can eliminate small, fragmented populations (Propst et al. 1992; Meffe and Carroll 1994). Specific criteria for size and hydrological complexity of watersheds to support desired abundance of populations and other demographic variables can be defined, and moni-
The management strategy is simple. First, state fish and wildlife agencies, together with USFWS and other federal land management agencies, identify which waters and watersheds will be devoted to exclusive management for native fishes, and which will be devoted to nonnative sport fishing. Then, beginning in the low order streams, barriers are installed, any native species are salvaged, nonnatives are chemically removed, and natives are repatriated or introduced from appropriate stocks. Barriers then are emplaced in higher order streams and upstream reaches are reclaimed. Through this process, native fish populations are interconnected once again, and exchange of individuals is possible. The number of tributaries treated and the order of the stream on which the downstream-most barrier is located would be determined on a case-by-case basis, as would the species or species assemblage to be restored to each interconnected stream system. Ideally, each imperiled native fish population would be replicated into one or more such restored and protected systems. Finally, simple and inexpensive monitoring protocols to detect nonnative reinvasion of reclaimed reaches must be established to ensure long-term accomplishment of the program’s goals.

In sum, management agencies need to designate watersheds or sub-watersheds for exclusive establishment of either native fisheries or nonnative sport fisheries. There is just no other way to retain both fishery types. This will entail some compromise by sportfishing interests and a shift in paradigm amongst management agency personnel. However, native fishes in the region have for too long been compromised by the continuing development of nonnative sport fisheries, and parity for native species needs to be established. Recreational fishing should be closed on waters designated for native fishes, or regulations promulgated to reduce potential for transfers of undesired species, which is proportional to angler use (Ludwig and Leitch 1996).

**Institutional Conflicts**

Resolving the biological conflicts is largely a technical matter. Resolving the institutional conflicts, however, is a political and social matter. A first step is a strong policy statement in support of nongame native fishes. Such a statement must come first from the states, because only they have a broad mandate and authority to manage the aquatic resources within their respective borders. The statement should make it clear that the standing of native species has been elevated to a position at least comparable to that of introduced sport fishes. The ESA already sets a basic federal policy mandating precedence of listed fishes over sport fishing. Then, beginning in the low order streams, barriers are installed, any native species are salvaged, nonnatives are chemically removed, and natives are repatriated or introduced from appropriate stocks. Barriers then are emplaced in higher order streams and upstream reaches are reclaimed. Through this process, native fish populations are interconnected once again, and exchange of individuals is possible. The number of tributaries treated and the order of the stream on which the downstream-most barrier is located would be determined on a case-by-case basis, as would the species or species assemblage to be restored to each interconnected stream system. Ideally, each imperiled native fish population would be replicated into one or more such restored and protected systems. Finally, simple and inexpensive monitoring protocols to detect nonnative reinvasion of reclaimed reaches must be established to ensure long-term accomplishment of the program’s goals.

In sum, management agencies need to designate watersheds or sub-watersheds for exclusive establishment of either native fisheries or nonnative sport fisheries. There is just no other way to retain both fishery types. This will entail some compromise by sportfishing interests and a shift in paradigm amongst management agency personnel. However, native fishes in the region have for too long been compromised by the continuing development of nonnative sport fisheries, and parity for native species needs to be established. Recreational fishing should be closed on waters designated for native fishes, or regulations promulgated to reduce potential for transfers of undesired species, which is proportional to angler use (Ludwig and Leitch 1996).

**Institutional Conflicts**

Resolving the biological conflicts is largely a technical matter. Resolving the institutional conflicts, however, is a political and social matter. A first step is a strong policy statement in support of nongame native fishes. Such a statement must come first from the states, because only they have a broad mandate and authority to manage the aquatic resources within their respective borders. The statement should make it clear that the standing of native species has been elevated to a position at least comparable to that of introduced sport fishes. The ESA already sets a basic federal policy mandating precedence of listed fishes over sport fishing. Then, beginning in the low order streams, barriers are installed, any native species are salvaged, nonnatives are chemically removed, and natives are repatriated or introduced from appropriate stocks. Barriers then are emplaced in higher order streams and upstream reaches are reclaimed. Through this process, native fish populations are interconnected once again, and exchange of individuals is possible. The number of tributaries treated and the order of the stream on which the downstream-most barrier is located would be determined on a case-by-case basis, as would the species or species assemblage to be restored to each interconnected stream system. Ideally, each imperiled native fish population would be replicated into one or more such restored and protected systems. Finally, simple and inexpensive monitoring protocols to detect nonnative reinvasion of reclaimed reaches must be established to ensure long-term accomplishment of the program’s goals.

In sum, management agencies need to designate watersheds or sub-watersheds for exclusive establishment of either native fisheries or nonnative sport fisheries. There is just no other way to retain both fishery types. This will entail some compromise by sportfishing interests and a shift in paradigm amongst management agency personnel. However, native fishes in the region have for too long been compromised by the continuing development of nonnative sport fisheries, and parity for native species needs to be established. Recreational fishing should be closed on waters designated for native fishes, or regulations promulgated to reduce potential for transfers of undesired species, which is proportional to angler use (Ludwig and Leitch 1996).
programs and USFWS has an Office of Endangered Species that promote a perception that native fishes are afforded independent attention. However, the fact remains that decisions are made at higher administrative levels by individuals who are subject to political and economic pressures that usually favor sport fishes.

Conclusions

Sportfishing has a long tradition in this country, but it is merely recreational pursuit, albeit an economically important one. To our knowledge, there are no major state or federal laws that require maintenance of sport fisheries. In contrast, imperiled fishes are protected under ESA, which legally reflects the wishes of the people of the United States. ESA was passed with overwhelming support from Congress, and has been the subject of repeated assaults. Yet, it remains with continued strong support from the people. Unfortunately, implementation of the ESA in the southwestern United States has not resulted in measurable improvements in the status of most listed fishes chiefly because agencies have been in denial regarding the overwhelming impact of nonnative species on native species (Minckley and Rinne 1991; Fagan et al. 2002).

We applaud those efforts by state and federal agencies to conserve and recover native imperiled fishes. There are success stories in the 30-plus years since passage of the ESA, and more to come in the future. Nonetheless, most listed fishes in the region have diminished in extent of range from the time of their listing, and many other non-listed species are in decline and may qualify for federal listing, but have not yet been afforded that protection.

Changes must occur if native southwestern fishes are to persist. Status quo is simply not good enough. We believe, in fact, that maintenance of status quo for many of these species will result in a downward spiral to extinction. We recommend elimination of biological conflicts between native nongame fishes and nonnative sport species by implementing segregated management—watersheds dedicated to one kind or the other. We further recommend ameliorating institutional conflicts by reorganizing agency infrastructures to ensure autonomy of native fish programs and personnel, and dedicated funding for nongame fish programs.

In the words of the late W. L. Minckley, a renowned advocate and conservator of southwestern native fishes, “Native fishes of the American West will not remain on earth without active management, and control of nonnative, warmwater species is the single most important requirement for achieving that goal” (Minckley 1991:145). We believe our approach of segregated fisheries will accomplish this management with the least impact to existing sport fisheries, and is a realistic and practical approach to fulfilling mandates of the ESA and the 1996 USFWS policy on recreational fishing.

Acknowledgements

This work benefited from discussions over many years with members of the professional community throughout the Southwest who routinely are confronted with native and nonnative sport fish issues and conflicts. We thank two anonymous reviewers for their constructive comments.


