

FEATURE

The Sport Fish Restoration Program as a Funding Source to Manage and Monitor Bowfishing and Monitor Inland Commercial Fisheries



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The Sport Fish Restoration Program (SFR) has been a stable and highly successful funding program supporting state fisheries research, propagation, and management activities since its inception in 1950. The expanding sport of bowfishing in the past 2 decades, and research over a comparable time period showing very long lifespans of underappreciated native fish species, opens the door to some new ways to classify, manage, and fund monitoring of these natives under the SFR program, while encouraging sport and commercial take of invasives. Evidence from bowfishing and from changes in angling patterns for some nongame species indicates that the time has come to consider reclassifying underappreciated native species into some form of sport status (entirely separate from non-native invasives) and thereby potentially expanding the scope of species projects financed with SFR funds. Reclassification will also function to upgrade the status of underappreciated native species taken within agencies, with bowfishers and anglers, and with the public. It then opens the door to improved, and necessary, monitoring of inland commercial fisheries (often targeting the same species), an activity which has needed improvement and a reliable funding source for decades. We suggest that our approach is a comparatively straightforward one that is scientifically defensible and implementable within the existing state–federal management jurisdictions and institutions.

INTRODUCTION

This article involves four aspects of modern inland fisheries management in the United States: the development and well-documented success of the *Federal Aid in Sport Fish Restoration Act* (often called the *Dingell–Johnson Act*) and its amendments (hereafter Sport Fish Restoration Program; Sousa 1982; Ross and Loomis 1999; American Fisheries Society 2000); the development of bowfishing and its rapid ascendancy into a modern sport (Scarnecchia and Schooley 2020); emerging conservation issues with underappreciated native species (Lackmann et al. 2019; Scarnecchia and Schooley 2020); and the importance of adequate state monitoring of inland commercial fisheries in the United States (Murray et al. 2020). Of the four, the first topic, the Sport Fish Restoration Program, is widely recognized as a valued funding source for fisheries research, propagation, and management, with a strong 70-year record of success (Lukens 1992; McMullin 2000; Peterson et al. 2000). In contrast, the other three topics are issues of concern, in large part because of a lack of adequate funding. Our intent here is to explore the evolving linkages among Sport Fish Restoration, the emergence of bowfishing as a modern sport in need of management, largely unexpected research results on the life histories of some underappreciated native/nongame species that call for new approaches for managing them, and the resulting need for more effective and detailed inland commercial harvest monitoring of those species. We suggest a realistic path toward improved effectiveness in all four of these aspects *within the existing federal–state fisheries funding and management framework*. We suggest that a major reconceptualization of the state management jurisdiction or a reworking of the federal–state funding structure of inland U.S. fisheries is not needed, as some fairly minor adjustments incorporating new scientific findings will accomplish many desirable goals and improve the situation for all four of these topics. Management entities seeking a common understanding of the issues is one step (Gray et al. 2020). We see nationwide applicability of our approach in all 50 states. The ideas here may be particularly important immediately throughout the Mississippi and Missouri river basins, the Red River of the northern USA in the Hudson Bay drainage, and Gulf Coast drainages because of the fisheries and species targeted there.

SPORT FISH RESTORATION AS A SUCCESSFUL PROGRAM AND FUNDING SOURCE

Since its inception in 1950, the Sport Fish Restoration Program has proven to be a vital, stable, and enduring source of funds aiding the states and U.S. territories including

Puerto Rico, Guam, American Samoa, and the District of Columbia in the sustainable management of fish populations, their fisheries, and their habitats (Sousa 1982; Bohnsack and Sousa 2000). Described by the U.S. Fish and Wildlife Service (USFWS, no date) as the most ambitious program for fisheries improvement that the United States has known, revenues generated by a 10% excise tax on fishing rods, reels, creels, and artificial lures, baits, and flies are paid to the U.S. Department of the Treasury by the manufacturers, and federal fuel taxes attributable to motor boats and small engines, which then are appropriated to the USFWS (Mosby and Gunn 1951; Radonski 2000). Other than a modest USFWS administrative fee (up to 6%, typically much less), the entire amount is earmarked for distribution to the states. A state's annual share of the revenue depends 60% on the number of its licensed sport fishers and 40% on its land and water area, with no state receiving more than 5%, or less than 1% of a year's available funds. States are required to use nonfederal funds, such as their fishing license funds to obtain the available excise tax funds from their federal aid allocation, typically on a 25–75% ratio, respectively. Total funds are then used to conduct a wide range of fish restoration and management activities, including research, fish stock assessment, habitat improvement, propagation, construction and improvement of fishing areas (Radonski 2000), and information and education.

Numerous amendments have occurred over the years. In 1984, the Wallop–Breux Amendment added a 10% excise tax to more items, added a 3% duty on some boat motors and fish finders (though not domestically built boats, boat trailers, or outboard engines), imposed import duties on fishing tackle, yachts, and pleasure craft, and diverted some motorboat and small engine fuel taxes to the Sport Fish Restoration Fund (Radonski 2000; Burger 2018). In recent decades, and with both major and minor amendments in Sport Fish Restoration, the states have become more diversified in how funds have been spent. The Wallop–Breux amendment directed states to use up to 10% of funds for boating access facilities and aquatic resources education programs (Available: <https://bit.ly/3hvi5SX>). In 1998, another amendment increased from 10% to 15% the amount states may spend for outreach and communications and increased from 12.5% to 15% the amount states must spend for boating access (Available: <https://bit.ly/3hvi5SX>). In the past 25 years, more emphasis has thus been put on stocking fish (Redmond 2000), on information and education (Forsrage and Farmer 2000; Kiefer et al. 2000; Richardson and Rushton 2000), and on boating, facilities infrastructure, and safety (Donheffner 2000; Hubbard 2000), always with an appropriate emphasis on improvement and restoration of sport fisheries.

Through the decades, some demographic factors have affected the program, as an aging and increasingly urban human population has decreased the number of licensed anglers and led to changes designed for “recruitment, retention, and reactivation... of anglers” (Kisonak 2021). Yet the essence of the program has persisted. As described by the USFWS, “This concept, and the program itself, have remained essentially unchanged in the past 4 decades. The Sport Fish Restoration Act has remained one of America’s most effective, yet quietist, success stories in natural resource conservation” (USFWS, no date). The program has been described as “user pays, public benefits” (Kisonak 2021). As of 2021, the program is jointly administered with the comparable Federal Aid to Wildlife Restoration Program by the USFWS from Falls Church, Virginia, as the Wildlife & Sport Fish Restoration Program (<https://www.fws.gov/wsfrprogram/>). In 2020, total Sport Fish Restoration Program funding to states and territories was just under US\$370 million (U.S. Department of the Interior 2020).

Sport Fish Restoration funding was a welcome and necessary infusion of support to the states with their management authority and myriad management responsibilities (Bohnsack and Sousa 2000; McMullin 2000). As described by Moffitt et al. (2010), “Even though authority for sport fish management was established for the states..., there was little money available for inland fisheries research and monitoring in the early 20th century. The financing was generally derived from license sales, and there was difficulty in establishing infrastructure in ... states.” State reliance on license sales, with just a few exceptions in states such as Missouri (Kisonak 2021), their limited availability of extracting adequate license revenue from users, and the inability of states to deficit spend, greatly hindered their financial and revenue-generating capabilities. The modest funding was inconsistent with the many Public Trust fisheries conservation and management responsibilities left unidentified as federal jurisdiction under the U.S. Constitution and conveyed to the states upon statehood along with the direct ownership of natural resource assets within their boundaries.

The Sport Fish Restoration funding strengthened state fisheries programs by providing the stable financial base needed to develop their conservation programs, institutional structures, and agency personnel expertise (e.g., Missouri: Novinger 2010). King (1952) reported that “seldom have the individuals—administrators, technicians, laborers... and fishermen—engaged in fish conservation been so stimulated as they have been by the discussions, observations, and active planning related to Federal Aid to Fish Restoration.” By the end of the 20th century, Ross and Loomis (1999) estimated that Federal Aid funds and license sales accounted for an average of 41% and 42%, respectively, of the total funds available to states. With the Sport Fish Restoration Program in place, fishing license fees also avoided diversion into other activities, which had often happened in the past.

Despite some important (though not widely available) articles on the importance of Sport Fish Restoration funding (Bohnsack and Sousa 2000; McMullin 2000; Peterson et al. 2000), the program’s impacts on the development, stability, and evolution of state fisheries programs are likely underappreciated by the general public. Even with efforts to publicize the Sport Fish Restoration Program, anglers and boaters pay the excise tax and federal fuels tax often without realizing their purchases contribute to the Sport Fish Restoration Fund. Similarly, many fisheries professionals not in administrative positions do not fully understand the

importance of the program. This underappreciation may stem from the more diverse state-level approaches to reporting and describing fisheries management, whereas federal and federally sponsored investigations and management are presented in a more regional, unified, and holistic way. For example, Moffitt et al. (2010) provided a well-researched overview of early inland fisheries investigations and management in North America, describing in detail activities conducted by the U.S. Fish Commission, ichthyological surveys sponsored by the Smithsonian Institution, and activities at various federal labs and universities. State activities are also covered, although their historical activities, often not well documented, seem more fragmented and uncoordinated, a persistent issue compounded by low levels of state funding provided for multi-state coordination and broader communication.

SPORT FISH RESTORATION AND THE REST OF THE FISH

On which activities and fish species the states have spent these funds has evolved over the decades. In the fiscal year ending June 30, 1952, the first funding year of the program, 94 of the first 154 projects approved dealt specifically with fish investigations. As required in this user pays approach, inland projects in the first year appropriately emphasized pond, lake, reservoir, stream, and river survey work, as well as restoration and enhancement of popular species in sport fish families including Salmonidae, Centrarchidae, and Percidae. Initial survey work by states in their earlier years of the program was followed by an increase in actual management activity on the many newly built, often publicly funded, ponds and larger reservoirs (Redmond 2000).

From the inception of Sport Fish Restoration, there was a rather well-defined distinction between fish species favored and not favored under the program. Longstanding sport species and species providing important forage for those species were favored for funded enhancement and restoration programs. Other studies were concerned with control of less valued or undesirable fish species, variously called commercial, “rough,” or “trash” fish (King 1952). These species were typically perceived either as of only commercial value to be sold “in the rough” (whole), commercially useless, or in many cases inimical to sport fishing. This distinction may have derived, in part, from the common practice of defining sport or game fish species in state statutes. Species not listed as sport or game fish were, by default, classified as “nongame” or “commercial.” A few invasive species such as the Common Carp *Cyprinus carpio* were included as nongame, but this group was mostly native species, including the gars (Lepisosteidae), Bowfin *Amia calva*, Freshwater Drum *Aplodinotus grunniens*, and numerous sucker (Catostomidae) species, including buffalofishes *Ictiobus* spp., redhorses *Moxostoma* spp., and carpsuckers *Carpionodes* spp. These are native fish taxa long established in the North American fossil record as part of the diversity of aquatic ecosystems (gars: Cretaceous, Wiley 1978; Bowfin: Cretaceous, Grande and Bemis 1998; Catostomidae, Late Cretaceous–Eocene, Bagley et al. 2018; *Ictiobus*: Pliocene, Alvarado-Ortega et al. 2006). Despite their ancient lineages and important contributions to aquatic community biodiversity and ecosystem function (Scarnecchia 1992; Cooke et al. 2005), many of these same fishes have been taken and thrown away, and sometimes destroyed indiscriminately. Some of these same native species were also harvested commercially, a practice continued up to the present in many states (Klein et al. 2018).

Occasionally, some species have come to be characterized as sport/commercial fish. For example, the Channel Catfish *Ictalurus punctatus* has developed a well-defined dual identity as sport/commercial fish (e.g., Missouri, Tennessee). In most states they have recognized sporting value, are classified as sport fish, and are therefore eligible for funding under the *Sport Fish Restoration Act*. However, they have also been classified in some states as a commercial fish in areas where their perceived abundance exceeded the needs for sport use. Channel Catfish are accordingly raised and stocked in state fish hatcheries partially or fully funded by the *Sport Fish Restoration Act* to establish or enhance a sport fishery for them. Another example has been the ancient Paddlefish *Polyodon spathula*, for which improved access to fish below dams by recreational snag anglers led to a reclassification of the fish into a sport fish in many states (Mestl et al. 2019). However, it retains its commercial status in eight states (Rider et al. 2019). This transition from a commercial fish into a sport fish (e.g., Channel Catfish, Paddlefish) to a protected fish (if necessary) was seen as a somewhat predictable pattern characterized by anthropologist Smith (1986) as a function of the number of people pursuing the fish in a region compared to the number of fish available to meet demand (Figure 1). Catfishes and Paddlefish have also become viewed more widely as sport fish as commercial fisheries in particular states have closed (e.g., Oklahoma).

Over the 70 years of Sport Fish Restoration, very few fish species have changed in their state-designated classifications, and perhaps more importantly, changed in angler perception or public perception. Rarely do fish classified as commercial, nongame, or rough/trash fish change into a sport fish (the exact terminology depending on the state and a person's perceptions).

As a result of the minimal reclassification of commercial, nongame, or rough fish into sport fish, most Sport Fish Restoration activities with these species have focused on controlling or eradicating them (Scarnecchia 1992; Lackmann et al. 2019). Most importantly, native species such as gars,

Bowfin, and suckers have typically been treated identically with regard to regulations and commercial sale as non-native invasives such as the Common Carp and more recent arrivals, including the Grass Carp *Ctenopharyngodon idella* (Mitchell and Kelly 2006) and bigheaded carps (Cyprinidae: Bighead Carp *Hypophthalmichthys nobilis*, Silver Carp *H. molitrix*, and Black Carp *Mylopharyngodon piceus*; Nico et al. 2005; Kelly et al. 2011; Kramer, et al. 2019). No well-defined, ecologically defensible distinction is being made between removal of native species and the more beneficial removal of the invasive species (Bouska et al. 2020), even though the number of invasives has increased greatly in the past 2 decades (e.g., Illinois River; Solomon et al. 2016). As of 2021, with very few exceptions, underappreciated native fishes previously viewed as, or still considered rough or commercial fish—gars (other than the Alligator Gar *Atractosteus spatula*), Bowfin, buffalofishes and other suckers, and Freshwater Drum—continue to be taken in largely unregulated numbers in commercial fisheries and bowfisheries (Scarnecchia and Schooley 2020). This trend is particularly concerning considering the catastrophic declines of native freshwater fishes worldwide (WWF 2021), and that 55% (42 of 76) of North American catostomids are already imperiled (Harris et al. 2014).

THE ASCENDANCY OF SPORT BOWFISHING FOR UNDERAPPRECIATED NATIVE QUARRY

It has been primarily through the ascendancy of bowfishing and bowfishers' chosen quarry that many underappreciated native inland species have attained recognition and valid status as sport fishes in the bowfishing community, even if they remain classified as nongame fishes in many states. Amid the development and successes of Sport Fish Restoration in the 1950s through the early 2000s, bowfishing, the taking of a fish with bow and arrow, had a steady but moderate growth period. As is detailed in a recent comprehensive review of the sport (Scarnecchia and Schooley 2020), interest in bowfishing throughout the half century was maintained through a range of popular articles targeting both men and women bowfishers, mostly in archery or bowhunting magazines (Figure 2A; Shore 1993). Interest in bowfishing was scattered and not particularly well documented. The only periodical magazine dedicated to the sport, *Bowfishing* magazine, published by Paul Shore in Wisconsin, was not profitable and was discontinued after only about 3 years (1986–1988; Figure 2B). Fish taken by bowfishers were a low priority to fish managers. It was during this period, however, that the invention and refinement of the compound bow and its acceptance as a sporting method opened the sport of bowfishing to a much larger fraction of the public over the period 1970–2000, setting the stage for expansion of the sport in this century.

In the first 2 decades of this century, interest in the sport of bowfishing increased rapidly; advances in bowfishing technology, internet websites advertising bowfishing successes, and broad legalization of night bowfishing along with extended shooting seasons have led to a proliferation of guide services and a greater bowfishing impact. Bowfishing by its nature and gear is removal-based (Figures 3, 4). It is a catch-and-kill sport; there is no legitimate catch and release. Bowfishing impact on the native environment is thus likely amplified compared to other, more traditional sport fisheries. Bowfishing tournaments exhibit several activities—weigh-ins, prizes, competition, and spectators—found at more traditional sport fishing events such as bass, crappie,

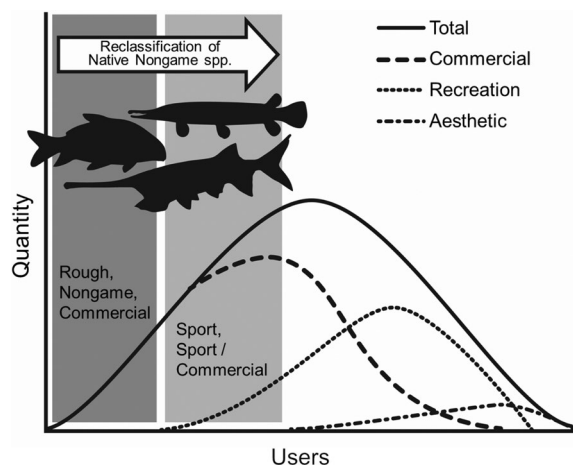


Figure 1. Generalized life cycle process showing total available for a hypothetical fishery, and the relative shares for commercial, recreational, and aesthetic uses as the number of users increases. It is suggested that a reclassification of native, nongame species as sport or commercial sport fish is warranted as sporting interest has substantially increased (Scarnecchia and Schooley 2020), and to distinguish them from non-native invasive species. Figure modified from Smith (1986).

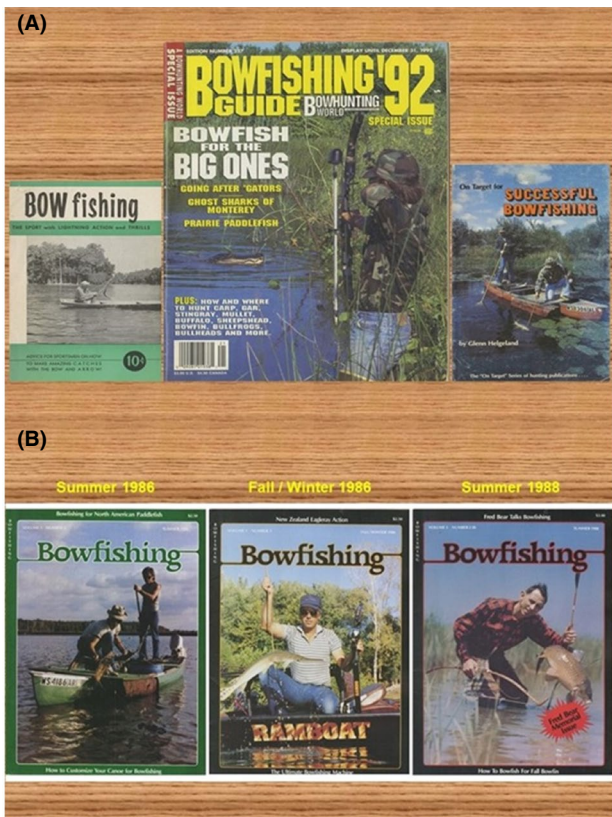


Figure 2. Bowfishing information in the mid to late 1990s was (A) scattered in pamphlets, archery and bowhunting magazines, a few special issues, and a few books except for (B) Paul Shore's *Bowfishing* magazine, published from 1986 to 1988. Interest accelerated greatly in the era of the internet.

and Walleye *Sander vitreus* tournaments. Yet over the past 2 decades, amidst this rapid growth in sport bowfishing and in organized tournaments, there has been essentially no management and stock assessment for those native species taken



Figure 3. The maturation of Sport Bowfishing in the 21st century as depicted at the 2018 U.S. Open Bowfishing tournament in Broken Arrow, Oklahoma. (Available: <https://bit.ly/3llvyu1>).

by bowfishers, an issue only recently identified as a serious shortcoming in the United States (Scarnecchia and Schooley 2020).

Of specific importance in the bowfishing review was the list of the native species targeted by bowfishers and what recent scientific investigations have revealed about these fish. These native species are being identified as having much longer lifespans and slower life history pace than formerly recognized (e.g., Bigmouth Buffalo: validated ages of up to 100+ years, the oldest age-validated freshwater fish; Black Buffalo *Ictiobus niger*: a sole specimen from Michigan aged at 56 years [Lackmann et al. 2019]; a Smallmouth Buffalo *I. bubalus* specimen from Oklahoma aged at 62 years [Snow et al. 2020]; Blue Suckers *Cycoreptus elongatus* aged up to 42 years [Radford et al. 2021]). These species mature at much older ages than formerly recognized, often show irregular recruitment, and exhibit sexual size dimorphism, with the largest fish removed being old females (Scarnecchia and Schooley 2020). The removal of the largest females is consistent with global trends and the well-documented global declines of freshwater megafauna (He et al. 2019). Evidence in the review by Scarnecchia and Schooley (2020), however, is that Paddlefish, Alligator Gar (Figure 5), buffalofishes, and other species, despite their neglect by many managers, have gained a new identity with the sporting public, and have become valuable and appreciated *de facto* sport fish in many localities throughout their ranges (Figure 6).

Although most of the new status of underappreciated native fishes now being considered sport fishes can be attributed to bowfishing, angling and other fishing practices for non-traditional species has increased. Angling for gars, Bowfin, and suckers has long been practiced (Scarnecchia 1992) and has become more popular in recent years, as evidenced by numerous websites and YouTube videos. For example, in southeastern Alabama, a winter (January–March) sucker fishery exists where Blacktail Redhorse *Moxostoma poecilurum* and Spotted Sucker *Minytrema melanops* are the main catches. Anglers with a sportfishing license are permitted to use gill nets to catch these species in the tributaries of several rivers in the region. They also use rod and reel with small hooks baited with meal worms or dough balls to catch this



Figure 4. Specially designed bowfishing watercraft with custom seating and lighting (and gar artistry) attests to the maturation of the sport and its interest in native species. (Available: <https://bit.ly/3hRbN2l>).



Figure 5. Trophy bowfishing for Alligator Gars. This species has come under recent management as a species for which judicious harvest requires careful stock assessments (Scarnecchia and Schooley 2020). Available: www.garfishingguide.com.

local delicacy. This is another example where a strictly sport or commercial classification does not exist as sport anglers are using traditional commercial gear. Another designated commercial/nongame fish species in Alabama, the Bowfin, is popular in the Mobile Delta (Baldwin and Mobile counties) for several sport fish “Bowfin only” tournaments held each year. These tournaments are becoming more popular as Bowfin are increasing in recreational value as more anglers are actively targeting this species. This ancient species is also being targeted by commercial fishers for caviar and may consist of more than one distinct species (Polumbo 2016; Sinopoli and Stewart 2021). One only has to peruse online social media to see the various sport groups and individuals that are now targeting many different native fishes not traditionally thought of as sport fishes.

Historically, state classification of a fish species as either sport or something else was, and remains, the principal determinant of whether Sport Fish Restoration funds are used for research, management, and monitoring of that species. Sport fish are defined under the Sport Fish Restoration Program as “aquatic, gill-breathing, vertebrate animals with paired fins, having material value for recreation in the marine and freshwaters of the United States” (<https://bit.ly/3zp1Gbc>). In conversation with state agency managers, states differ in their views of how restrictive this definition of “sport” is to their activities under their state-specific statutes, which often differ in how they classify fish species. Some states did not indicate that their state classification of species was particularly restrictive to their ability to fund Sport Fish Restoration projects (e.g., Texas:

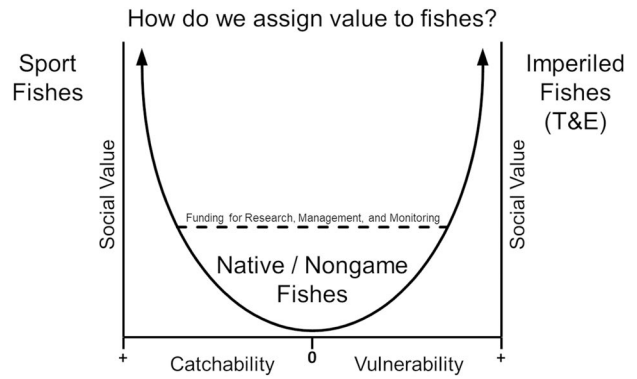


Figure 6. The historically low social value attributed to native/nongame fishes as having low catchability/angler interest and low vulnerability to depletion (i.e., ubiquity and resiliency) has led to their designation as rough or trash fishes deserving little or no management effort or funding. These sentiments have also led to regarding these fishes as largely unworthy of monitored commercial harvest. Scientific evidence in the past 20 years on longevity and recruitment suggests that this view of native/nongame species is erroneous and inadequate for sustainable management. Further, the more recent expansion of bowfishing in the United States has likely imparted substantial recreational value upon these species often targeted by the sport. Evidence indicates that many native/nongame species (e.g., gars and buffalofishes) are of substantial value and deserving of funding due to both their catchability and vulnerability.

D. Buckmeier, Texas Parks and Wildlife Department, letter of March 25, 2021 to DLS; Ohio: R. Zweifel, Ohio Department of Natural Resources, letter of March 25, 2021 to DLS; Indiana: J. Caudell, Indiana Department of Natural Resources, letter of April 21, 2021 to DLS). Other states, including the eight states participating in this paper, and some others, as well as those with different statutes and administrative rules see some re-classification as providing more flexibility (Nebraska: K. Steffensen, Nebraska Game, Fish, and Parks, letter of April 5, 2021 to DLS). Reclassification is a key step in changing species perceptions; it may enhance their ability to respond to additional needs brought about by the ascendancy of sport bowfishing (Wisconsin: J. Hasz, Wisconsin Department of Natural Resources, letter of April 1, 2021 to DLS) and other non-traditional recreational angling of fishes (e.g., angling for buffalofishes; micro-fishing: Cooke et al. 2020) not previously seen as worthy of Sport Fish Restoration funds for management.

It is time for states, as well as federal management agencies such as the USFWS, to ask if these underappreciated native species and stocks of gars, Bowfins, buffalofishes and other suckers, and others are not only eligible, but worthy, of Sport Fish Restoration-funded stock assessments and management comparable to that received by traditional sport fishes such as salmonids, basses, and Walleye. Their sport status is well supported by both social and economic evidence. Tackle and fuel expenditures by sport anglers pursuing species such as gars and catfishes, for example, greatly exceed such expenses by commercial fisherman harvesting them.

Issues of fish classification as it affects wanton waste are also relevant. Some state laws on wanton waste differ depending on the classification of the fish. In some states it is illegal to waste sport fish but not non-sport fish (West Virginia: K.

Zipfel, West Virginia Department of Natural Resources, letter of March 23, 2021 to DLS). Other states have very liberal laws regarding wanton waste; native fish may be used as fertilizer. The North American Model of Wildlife Conservation (Available: <https://bit.ly/3lJdVKG>) that guides state and federal natural resource agencies in managing, conserving, and preserving fish and wildlife is based on principles codified in the *Migratory Bird Treaty Act of 1918*, the *Migratory Bird Hunting and Conservation Stamp Act of 1934*, the *Federal Aid in Wildlife Restoration Act of 1937*, and the *Federal Aid in Sport Fish Restoration Act of 1950*. The Model notes that fish and wildlife are public resources that should not be killed for frivolous reasons. Under this prevailing conservation philosophy, should not unregulated bowfisheries, as with fish removal projects, be focused on non-native invasives while minimizing effects on the underappreciated native species? Scientific and socio-economic information suggest that an upgrade in the status of the native fishes is warranted (Scarnecchia and Schooley 2020).

States should seriously consider, if needed, formally reclassifying the native species as either sport fishes, sport/commercial species, or sport fishes with special fishing methods, and leave unregulated fisheries and eradication efforts to non-native invasives (Figure 1). If complete designation as a sport fish is not preferred in some states, as is the case for Channel Catfish and Paddlefish in states with commercial harvest or where the legality of preferred angling methods is defined by species class, at least their designation as a sport/commercial fish or a special class of sport fish would separate them from non-native invasive fishes and enable their monitoring and management under Sport Fish Restoration.

Several other suggestions related to Sport Fish Restoration for proactively managing bowfisheries and for funding the management of underappreciated native species are provided in Scarnecchia and Schooley (2020). One such idea is the possibility of requiring bowfishing licenses. Another is the more equitable use between bowfishing and bowhunting of archery equipment excise taxes long collected under the Pittman–Robertson Program, with only a fraction of bowfishing equipment taxes being provided to the Sport Fish Restoration accounts (Scarnecchia and Schooley 2020). An additional advantage of working through Sport Fish Restoration is that “the ... program also allows [the use of] donated funds, goods, and services that are necessary and reasonable to accomplish the project objectives to serve as the state fisheries agencies cost share” (Bohnsack and Sousa 2000). The program can therefore serve as an efficient conduit for donated funds from other sources besides license sales as they become available, with the additional benefit of USFWS oversight. As of 2021, substantially more funds are projected to be entering the program (<https://bit.ly/39iqLdc>).

There are several conservation benefits to such actions. In addition to the more justifiable use of Sport Fish Restoration funding, it sends a message to bowfishers, anglers, and the wider public that these underappreciated native fish, many of which are very long-lived, have ecological and societal value as part of the native biota. It is difficult to expect bowfishers, commercial harvesters, or the public to show adequate regard for gars, Bowfin, native suckers, and other historically underappreciated fish if the managers regard them as worthless or undesirable, classify them the same as non-native invasives, and thus undertake little or no monitoring or management. A social value upgrade for these species is unlikely to occur without direct action or example set by management agencies

demonstrating their value. With the pressure on many long-lived, native species (Lackmann et al. 2019) brought by new fisheries (Scarnecchia and Schooley 2020) and invasives (Solomon et al. 2016), it may also be a prudent, proactive step to avoid any species or stock declines that may result in proposals to list them as Species of Concern, threatened or endangered. State managers can thus remain in their lead role as harvest managers and avoid being in the role of assisting federal scientists in the more difficult task of salvaging much depleted native fish species that were in the past seen as abundant nuisances and wasted (Figures 7 and 8).

A NECESSARY NEXT STEP TO NATIVE UNDERAPPRECIATED SPECIES CONSERVATION: INLAND COMMERCIAL FISHERIES MONITORING

The increasing popularity of underappreciated species by bowfishers (and anglers) also provides a vital, scientifically justified, and necessary bridge to address another chronic problem of underfunding: state monitoring of inland commercial

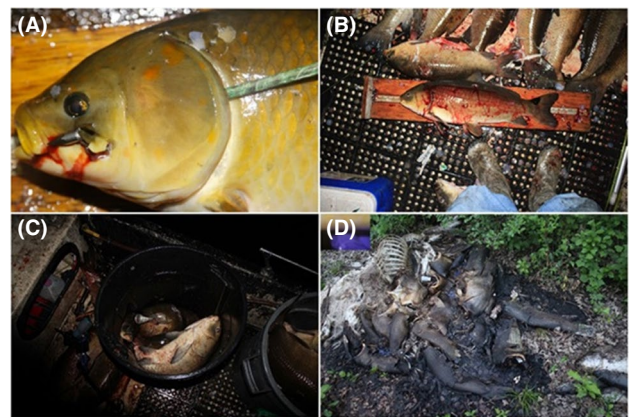


Figure 7. A common bowfishing cycle for the longest-lived freshwater fish (as of 2021): (A) Fish are shot and gaffed, like this 95-year-old male Bigmouth Buffalo (Lackmann et al. 2019), (B) laid out for pictures, (C) thrown into large (208 L) refuse barrels with garbage, and (D) their full-bodied fish carcasses discarded and left to decompose.



Figure 8. Wanton waste of native Bigmouth Buffalo ($n = 32$) documented by bowfishers in Minnesota in 2020. More than 2,500 life-years taken in 1 night of bowfishing; the median age was determined as 89 years old (A. Lackmann, personal communication). Wanton waste laws often differ among states according to their classification as sport fish or not.

fisheries. The commercial harvesters and bowfishers are in conflict with one another, perhaps unnecessarily, in large part because there is so little regulation or knowledge on each entity's effects. They are competing for the same public resources and no one knows how much of these resources exist, nor how much each group is actually exploiting. Further, one group uses the fish for food and in some cases their sole or primary livelihood, while the other largely kills them for sport (not food) and disposes of the full-bodied carcasses (Figures 7, 8), thereby increasing animosity and potential conflict. To be equitable, just as bowfishing needs to be monitored for take of underappreciated native species, so do commercial fisheries.

Funding for commercial fisheries monitoring and management within individual states, which need to balance budgets, is very limited, however, and consists entirely of state-generated funds. There have been very few good external sources of support for stock assessment and planning efforts for state commercial fisheries nationwide, with a few exceptions such as the Great Lakes fisheries. Sport Fish Restoration funding has generally not been available for other inland commercial fisheries. Although State Wildlife Grant Program (SWG) funds can in principle be used for underappreciated native fishes, SWG funding is focused on habitat management and species restoration for species ranked as "greatest conservation need" or "greater conservation need," i.e., for imperiled state-managed species to keep them from becoming listed under the *Endangered Species Act*. Underappreciated species taken by bowfishers, other sport fishers, and commercial harvesters will seldom rank high enough in a state's Wildlife Action Plan to justify using SWG funds until they are seriously depleted to the point of imperilment. This is typically too late for proactive harvest management.

The inland commercial fisheries (except for the Great Lakes) clearly exist in an administrative funding gap, a situation existing perhaps since their inception. Our evaluation of recent reviews of inland U.S. harvest (Murray et al. 2020) and Mississippi River commercial harvests (Klein et al. 2018) provide us with no evidence that the historical data collected for most inland commercial fisheries other than the Great Lakes are adequate for anything but the most cursory assessment of the fisheries or stocks; conclusions drawn by the authors were appropriately very modest. The data are grossly inadequate for native species stock assessments. For example, data such as total poundage by species group on fish tickets are unsuited to meaningfully assessing stock trends (e.g., self-reporting, or lumping "redhorses," "buffalo," etc. into bins is not adequate species-level reporting of commercial hauls). It is even less suited to assessing the complex relationships between non-native bigheaded carps and native zooplanktivorous buffalofishes, carsuckers, other catostomid species, and Paddlefish (Pendleton et al. 2017; Kramer et al. 2019).

Whereas we would suggest that state *management* of commercial fisheries is outside of the scope of Sport Fish Restoration funding, *monitoring* of the commercial harvest of those native species would be within the scope of Sport Fish Restoration funding to ensure sustainability of the sport fisheries for the native species. Such examples with Sport Fish Restoration funding exist in the fisheries literature for traditional sport fishes (e.g., Kentucky Lake, Kentucky, and Tennessee; Timmons et al. 1989). This interpretation is fully consistent with language in the legislation and amendments where funds can be used to address issues affecting the sport species of interest. It would also be a meaningful step toward addressing the well-known funding shortages associated with

inland commercial fish harvest in North America, especially outside of the Great Lakes.

Our suggested approach is to link Sport Fish Restoration with the expanding sport of bowfishing, sportfishing for underappreciated native species, the needs for stock assessment, and management needs for the native species that are now targeted and then link the needs of bowfishing management with commercial fisheries monitoring (not management), as diagrammed in Figure 9. Multi-state organizations of state managers such as the Association of Fish and Wildlife Agencies (AFWA), its regional organizations (e.g., SEAFWA, MAFWA), and the Mississippi Interstate Cooperative Resource Association (MICRA) can assist the states in fulfilling their mandated in-state management roles. Equally vital would be their multi-state cooperation with each other and with federal agencies such as the USFWS in inland fisheries management. Monitoring commercial fisheries requires a consistent and stable funding source, which aptly describes Sport Fish Restoration and its role in sport fishing management. States and their working groups (AFWA, MICRA, etc.) can work with federal fisheries management agencies such as the USFWS to compile accurate and meaningful statistics at a national level for national and international publication by organizations such as NOAA Fisheries (Murray et al. 2020).

Our observations suggest that the types of fisheries discussed in this paper—traditional angling, bowfishing, and commercial—if conducted on the appropriate species with appropriate, well-articulated management goals, can each provide benefits of species conservation, public benefits, and sound long-term public policy. Bowfishing event monitoring and ride-alongs with commercial harvesters may present an opportunity for fisheries managers not only to collect data, but to begin to build relationships with and between bowfishers and commercial fisherman. Since these two groups harvest many species in common, future fisheries, particularly bowfisheries, could be configured to reduce waste of a public resource by making the catch available to commercial fisherman using appropriate permit systems. Doing so would benefit both sport and commercial fishers. The key is *fisheries design*. Liberal commercial fisheries and bowfisheries should be designed and promoted by agencies to assist managers in goals of invasive species elimination or, more realistically, reduction and maintenance control. In contrast, scientific evidence (Scarnecchia and Schooley 2020) indicates that more judiciously designed fisheries of all types are warranted for the native species, along with conscientious stock monitoring and assessments.

Our suggested approach is only one of many models that can improve much needed monitoring and management of bowfishing. Evidence indicates that bowfishing has matured to the point where it should be seen as a viable recipient of, and contributor to, funds of the Sport Fish Restoration Program. Evidence from the sport and from changes in angling patterns for some nongame species also indicates that the time has come to consider reclassifying underappreciated native species into some form of sport status (entirely separate from non-native invasives) and thereby expanding the scope of species projects financed with Sport Fish Restoration funds. It will function to upgrade the status of underappreciated native species taken. It recognizes the important ecological roles of native species in aquatic systems and the need for their sustainable management. It also opens the door to improved and necessary monitoring of inland commercial fisheries, an activity which has needed improvement but lacked adequate funding for decades.

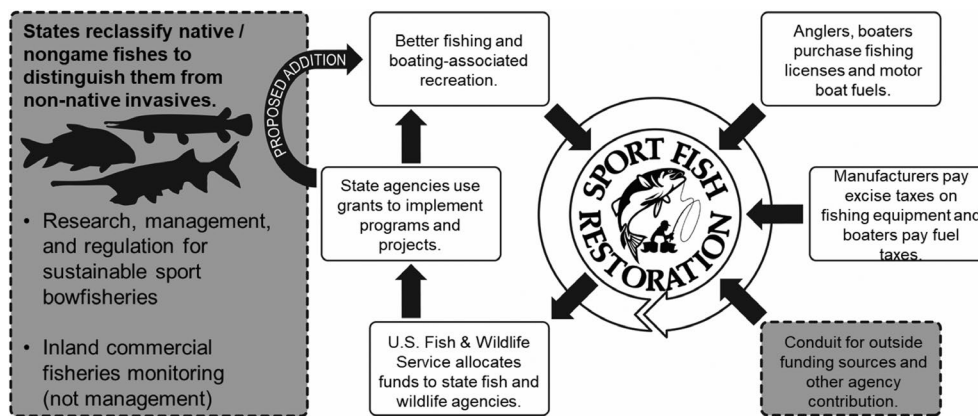


Figure 9. Diagram of how the Sport Fish Restoration Program may function as a viable solution to the rise of sport bowfishing, native species conservation, and inland commercial fisheries harvest monitoring. The central portion of the figure around the white arrow depicts the current program. The shaded, left portion of the diagram depicts the entry of bowfishing management and monitoring and commercial fish monitoring (not management) into the program. The shaded, bottom right portion depicts that the program is also a productive conduit for outside funds for sport and other native species. The Sport Fish Restoration portion is available: www.fws.gov.

The approach outlined here is left mainly in conceptual terms. Each state attempting to implement this general approach to improving management options and sustainability of bowfishing, native fishes, and inland commercial fisheries would do so within its own unique sociopolitical milieu, its existing statutes, and its administrative rules. For example, states vary in whether they classify fish strictly into the above categories (e.g., game, nongame, commercial, rough) and which species go into specific categories.

Our approach may not be the only viable model. For example, other papers have addressed the general issue of inadequately monitored and undermanaged inland fisheries at a broader, international, more abstract level (e.g., Beard et al. 2011; Cooke et al. 2016). Their overall conclusions about the problems and needs are not disputed here. However, we suggest that our approach is a comparatively straightforward one that is scientifically defensible and implementable within the existing state–federal management jurisdictions and institutions.

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