Ecological, Social, and Economic Issues Related to Bioinvasive Salmonid Species and the Preservation of Cutthroat Trout in the Western United States

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ABSTRACT—Ecological, social, and economic consequences of native cutthroat trout (*Oncorhynchus clarki*) declines and replacement by non-native salmonid species are relatively minor, and measurable effects on ecosystems are rare. Restoration efforts for cutthroat trout involve removal or control of bioinvasive salmonid species, but such efforts are costly, ongoing, and resisted by segments of society. Cutthroat trout declines are of little concern to much of the public because non-native salmonid species frequently have higher recreational values. Net economic benefits of preserving cutthroat trout are equal or less than for non-native salmonids. Realistic goals to preserve cutthroat trout that consider ecological, social, and economic issues are needed.

Introduction

Preserving native cutthroat trout (*Oncorhynchus clarki*) in their natural habitats is dependent on not only understanding ecological systems, but also social and economic issues. Our purpose is to describe ecological, social, and economic issues associated with control of bioinvasive salmonids in efforts to preserve native cutthroat trout in the western United States. Clear understanding of these issues is critical when planning restoration efforts for native cutthroat trout. This article is a synthesis of issues described in a published paper by Quist and Hubert (2004).

Cutthroat trout had the broadest distribution of any trout species in North America (Behnke 2002). Behnke recognized 14 subspecies of cutthroat trout, nearly all of which have been reduced to <5% of their distributions since settlement by Europeans. Two subspecies of cutthroat trout are extinct, three subspecies are federally listed as threatened, and several subspecies have been petitioned for protection under the Endangered Species Act.

Ecological Issues

A variety of factors have been associated with cutthroat trout declines, but the most significant impact may be interactions with non-native, bioinvasive salmonid species. Four non-native species have had the greatest impacts on native cutthroat trout: rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and lake trout (*Salvelinus namaycush*). Behnke (2002) stated “The greatest negative impact, however, has been introductions of non-native trout, especially rainbow trout, with which cutthroat trout hybridize; but also brown trout, which replace native cutthroat trout in larger streams; brook trout, which have commonly replaced cutthroat trout in small streams; and lake trout, which replace cutthroat trout in large lakes.”

The ecological argument for cutthroat trout preservation is limited if the focus is on ecosystem function (Quist and Hubert 2004). Replacement of cutthroat trout with non-native salmonid species may affect ecosystem function by altering energy and nutrient flow. Due to their similar ecology, replacement of cutthroat trout with rainbow trout or cutthroat trout x rainbow trout hybrids results in little or no measurable effects on ecosystem function. The ecology of brook trout is similar to cutthroat trout in stream systems and replacement of cutthroat trout by brook trout likely causes little change in energy flow, nutrient flow, or ecosystem productivity. However, changes in fish assemblage structure, including reduction in native cutthroat trout abundance, due to predation by adult brown trout and lake trout can result in alterations to ecosystem function. Lake trout pose a major threat to lentic ecosystems where cutthroat trout are native. Nevertheless, lake trout probably pose the lowest threat of the four non-native salmonids to the persistence of cutthroat trout subspecies because the lake trout is predominantly a lentic species.

Social Issues

The value placed on preservation of native cutthroat trout has increased among natural resource professionals, but public support generally differs. An understanding of public values related to cutthroat trout and bioinvasive salmonids is critical for obtaining support for preservation activities. Social values can be divided into four major categories: ethical, aesthetic, historical, and recreational (Quist and Hubert 2004).

Ethical values originate from the belief that organisms have intrinsic value and deserve protection from destruction by human activities. The notion that species' declines are an indicator of changes to overall environmental health and that humans have a moral responsibility to protect the integrity of ecological systems for future generations can also be considered an ethical value, and is the belief held by most ecologists. However, the public may not be supportive of these ethical values.

Aesthetic values are associated with observing the natural beauty of organisms in their habitats. Although viewing cutthroat trout is a popular activity in Yellowstone National Park, observing them is not a common activity elsewhere. Replacement of cutthroat trout with non-native trout has no effect on the scenic or aesthetic beauty of the landscape. Thus, there is little evidence to suggest that aesthetic values differ greatly between cutthroat trout and non-native salmonids.

Historical values represent the role of a species in the history of a particular water body, region, or individual. Cutthroat trout supported a few commercial and subsistence fisheries that helped shape local cultures, but the historical values of cutthroat trout to most of the public are either unknown or extremely low.

The social value with the greatest discrepancy between cutthroat trout and non-native salmonids is probably recreational angling. Cutthroat trout, rainbow trout, brook trout, brown trout, and lake trout support important recreational fisheries, but replacement of cutthroat trout with non-native species has generally had little negative effect or even positive effects on recreational fisheries in the perspective of many anglers. Cutthroat trout are often considered inferior to other non-native salmonids due to their perceived ease of capture, poor sporting ability (e.g., jumping ability, stamina), and low maximum length. This belief is reflected in angler surveys where there is either little preference among trout species or strong preference for non-native salmonids over cutthroat trout.

Economic Issues

Protection of native cutthroat trout from non-native, bioinvasive salmonids is related to economics (Quist and Hubert 2004). Net economic effects associated with bioinvasion of non-native salmonids into a cutthroat trout fishery are contingent on the values society places on each species. In economics, “substitution” reflects the concept where an alternative commodity substitutes equally for a commodity that has become depleted or too expensive to purchase or supply. Non-native salmonid species may be viewed as ecological and social substitutes in most ecosystems and their bioinvasion has no effect on net benefits from the fishery. Rainbow trout, brown trout, and even brook trout, are often preferred by anglers over cutthroat trout throughout the western United States and their invasion can result in increased economic benefits. Consequently, in most fisheries, there is little or no demand for cutthroat trout preservation and cutthroat trout preservation incurs only additional cost without concurrent economic benefit.

Control of Bioinvasive Salmonids

Once an introduced salmonid species has become naturalized, their removal is impossible except at small spatial and temporal scales. Active approaches for reducing or preventing interactions between non-native salmonids and cutthroat trout have become an important component of cutthroat trout preservation efforts. Reducing the effects of competition and predation on cutthroat trout has been successful in some ecosystems by removing the non-natives with gears, such as gill nets, trap nets, or electrofishing. However, complete removal of non-native species with such gears is not possible, so consistent, high levels of effort are needed to reduce the impacts of competition and predation. Such efforts to reduce the abundance of non-native salmonids can be resisted where sport fisheries for the non-natives have developed.

A common approach to the preservation of cutthroat trout in headwater streams is the intentional isolation of allopatric populations. This can involve the identification of remnant populations and construction of barriers to prevent upstream movement by non-native salmonids. Where non-native salmonids occur in headwater streams, attempts are made to remove them using toxicants, followed by restocking with cutthroat trout. Removing all non-natives from a stream segment is often difficult or impossible, even with multi-year treatments. Anglers may resist non-native fish removals and reintroduce non-native fish above barriers, thereby hindering efforts to re-establish populations of cutthroat trout. While barriers and re-establishment of cutthroat trout populations above barriers may protect cutthroat trout, protected populations may be too small or have inadequate habitat to enable long-term population viability, and barriers may deteriorate or fail during floods. Consequently, efforts to create isolated allopatric populations of cutthroat trout in headwater streams require consistent monitoring and frequent repetition following failed attempts.

Reality dictates that cutthroat trout preservation efforts incur significant costs that are ongoing. Obtaining funds for preservation of cutthroat trout is difficult for management agencies and nongovernmental organizations dedicated to the cause. There can be little or no social or economic support for control of rainbow trout, rainbow trout x cutthroat trout hybrids, brown trout, lake trout, or brook trout in many systems where sport fisheries for non-natives are valued. Control efforts can be justified based on evolutionary and ecological values, but these may not be recognized as important to the public or many anglers. Thus, management agencies and nongovernmental organizations interested in cutthroat trout preservation must convince the public that preservation activities are needed, responsible actions. Furthermore, agencies and nongovernmental organizations must be realistic and realize that only a relatively small number of cutthroat trout populations can be preserved in the long term, because the costs to preserve cutthroat trout are real and represent a significant fixed cost to management. Realistic goals and expectations and cooperative agreements must be established to assure that projects are completed, routine monitoring is conducted, success is objectively evaluated, and identified maintenance needs are instituted for each of the cutthroat trout subspecies.

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In Defense of Natives: Why Protecting and Restoring Native Trout Should Be Our Highest Management Priority

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ABSTRACT—Native salmonids, including both inland resident trout and anadromous Pacific salmon and steelhead, have declined sharply across the western United States due to overfishing, habitat degradation, and interactions with non-native fish. While fisheries managers, anglers, and conservationists generally agree that native trout should be preserved in core strongholds such as Yellowstone Lake, there remains considerable debate about the degree to which native trout should be restored to waters now dominated by non-native gamefish. In this paper, the author argues that native trout will eventually disappear from the West unless these constituencies work together to establish large, permanently protected native fish sanctuaries in places such as the headwaters of the Snake River drainage in northwest Wyoming and the Upper Henrys Fork drainage in eastern Idaho. The author cites ecological, scientific, economic, cultural, and moral/spiritual justifications for making native trout preservation a top management priority.

Status of Native Trout in the Western U.S.

Native salmonids have declined sharply across the western United States due to a combination of overfishing, habitat degradation, and interactions with non-native fish. These declines have occurred among both resident (Williams et al. 1989) and anadromous (Nehlsen et al. 1991) fish. Today, all native trout species in the West are in serious trouble, with nearly half now listed under the federal Endangered Species Act, and the remaining species petitioned for listing.

Even within the Greater Yellowstone Ecosystem (GYE), one of the largest intact temperate ecosystems left in North America, native trout now occupy just a small fraction of their historic range. While habitat degradation in the form of road building, logging, mining, grazing, and dam construction has played a major role in this decline, native trout have also declined within National Parks and Wilderness areas primarily due to interactions with non-native fish. Van Kirk (1999) found that native cutthroat (*O. clarki spp.*) have either been extirpated, declined in abundance, or had their migration patterns severely disrupted in 33 out of 41 sub-watersheds in the GYE. Among the most frequently cited impacts of non-native fish introductions are predation, hybridization, competition for food, competition for habitat, and disease transmission (Lassuy 1995).

Perhaps most alarming is the recent data showing steep declines in native cutthroat trout even in some of their core strongholds in the GYE. In Yellowstone Lake, home the world’s largest remaining population of genetically pure inland cutthroat trout, Yellowstone cutthroat trout (*O. clarki bouvieri*) have declined to their lowest level since 1959 as a result of heavy predation by non-native lake trout (*Salvelinus namaycush*) and a severe outbreak of whirling disease (*Myxobolus cerebralis)* (Koel et al. 2003). In the South Fork Snake River, home to the second largest fluvial population of Yellowstone cutthroat trout within their historic range (the Yellowstone River is home to the largest), cutthroat numbers have plunged by half since the 1980s, and non-native rainbow trout (*O. mykiss*) now outnumber native cutthroat for the first time (Idaho Department of Fish and Game 2003). And in still other eastern Idaho strongholds such as the Teton and Upper Blackfoot Rivers, Yellowstone cutthroat trout populations have crashed by more than 90 percent over just the past five years as a result of drought and a surge in non-native fish populations (Idaho Department of Fish and Game 2003b).

Native Fish Restoration: How Much is Enough?

Clearly, many native cutthroat trout populations are in danger of disappearing from the GYE over the next few decades unless dramatic actions are taken to protect them in their remaining strongholds and restore them where they have declined in abundance. While the vast majority of fisheries managers and anglers agree that native fish should be protected in places where they remain healthy (e.g. Yellowstone Lake), the degree to which native fish should be restored to waters now dominated by non-native gamefish such as rainbow, brown (*Salmo trutta*), brook (*Salvelinus fontinalis*), and lake trout remains hotly contested. To cite just a few recent examples, the angling community remains deeply divided over ongoing efforts to restore native westslope cutthroat trout (*O. clarki lewisi*) to 77 miles of Cherry Creek, a tributary to the Madison River in southwest Montana, by poisoning out non-native rainbow, brook, and cutthroat trout. Opposition to that project was so strong that one sportsmen's group filed an unsuccessful lawsuit to stop the project from proceeding (Williams 2002). Similarly, many anglers were incensed when the Idaho Department of Fish and Game (IDFG) announced an end to the brook trout stocking program in Henrys' Lake in the late 1990s in order to avoid possible negative interactions with native Yellowstone cutthroat trout. Responding to this outcry, the IDFG reversed course a few years later and resumed the brook trout stocking program, albeit at lower levels and with sterile fish (Thornberry 2002).

The debate over how high a management priority native fish protection and restoration should be continues despite the fact that the nation's leading fisheries conservation organizations have adopted strong native fish policy statements in recent years. For example:

- The American Fisheries Society calls on managers of recreational and commercial fisheries to "use practices that do not threaten the viability of populations of native species of aquatic and terrestrial organisms, their habitats, and their ecosystems (Kapuscinski and Hallerman 1990)."
- Trout Unlimited (TU) supports activities that protect and/or restore native biodiversity, including such actions as restoring native salmonid stocks to their formerly occupied habitats; eliminating non-native stocking where it could adversely affect native salmonid populations; and preventing native and wild salmonid stock introgression caused by mixing historically isolated populations of salmonids. While TU does not necessarily advocate the removal of wild, non-native salmonid populations from ecosystems where they are presently established, it acknowledges that it may be required on a case-by-case basis to protect

or restore native salmonids or endangered species (Trout Unlimited 1997).

- The Federation of Fly Fishers (FFF), "supports fisheries management policies that recognize the value of native species in their native habitats, and does not support management policies that threaten native species with degradation or extinction." As for restoring native species where they have declined, FFF acknowledges that the removal of introduced non-native species from specific streams may be required under some circumstances, but that should not be construed as an unwavering policy to eliminate all non-native fish everywhere (Williams 2001).

Reasons for Protecting and Restoring Native Fish

There are multiple reasons why fisheries managers, anglers, and conservationists should advocate for making native fish protection and restoration not just a high priority, but the *highest* management priority in waters where they persist. These reasons can be classified under the following headings: (1) ecological; (2) scientific; (3) economic; (4) cultural; and (5) moral/spiritual. Although there are also *legal* reasons for preserving native fish (e.g. the Endangered Species Act requires not only that listed fish species be protected, but also recovered), they have been omitted from this discussion because they are a product of the other justifications.

Ecological

This justification is based on the premise that native fish fill unique niches in the ecosystems in which they evolved. The role that native Yellowstone cutthroat trout play in Yellowstone Lake is a good example of this. Following the discovery of highly piscivorous non-native lake trout in Yellowstone Lake in 1994, researchers documented 42 bird and mammal species that utilize Yellowstone cutthroat trout as an important seasonal food source, including up to 20 percent of the Park's grizzly bears. But if lake trout, which live deep in the water column and spawn along submerged gravel shoals, were to displace cutthroat, which live near the surface of the lake and spawn in shallow tributary streams, these wildlife species would lose access to a major protein source (Varley and Schullery 1995).

Yellowstone Lake provides an obvious example of how the displacement of native cutthroat trout by non-native lake trout would cause a major trophic upheaval. But what about instances where one surface dwelling, tributary spawning native fish is displaced by another surface dwelling, tributary spawning non-native fish? An example of this is the displacement of native westslope cutthroat trout by non-native rainbow and brown trout in southwest Montana's Gallatin River. While it may not matter to an osprey or a river otter whether they feed on cutthroat or rainbow trout, there are other compelling ecological reasons why such a displacement could result in fewer fish in the longer term. For instance, research shows that in most cases, native cutthroat trout are less susceptible to whirling disease than rainbow trout (Hedrick et al. 1999). Also, because they evolved over thousands of years to survive and thrive in an environment characterized by frequent severe droughts and floods, native cutthroat trout are oftentimes better equipped than rainbow trout to survive a variety of extreme environmental conditions (Behnke 1992).

Scientific

This justification is predicated on the belief that all native species should be preserved because they contribute to the overall scientific body of knowledge and help foster a better understanding of the way ecosystems work. Congressman John Dingell of Michigan, one of the original sponsors of the Endangered Species Act, articulated this justification eloquently when he said, “Living wild species are like a library of books still unread. Out heedless destruction of them is akin to burning that library without ever having read its books. Preventing the extinction of our fellow creatures is neither frivolity nor foolish environmental excess; it is the means by which we keep intact the great storehouse of natural resources that make the progress of medicine, agriculture, science, and human life itself possible (Rohlf 1989).”

Scientists are continually discovering new things about how ecosystems function by studying native salmonids. For example, through recent research that traces the movement of certain stable isotopes of carbon and nitrogen from marine to terrestrial environments, biologists now have quantitative evidence showing the key role that Pacific Northwest salmon play in growing exceptionally large trees (Cederholm et al. 1999). As a result of this research, commercial timber companies now dump surplus hatchery salmon carcasses into streams that flow through their private timberlands.

Another way scientists use native salmonids to conserve ecosystems is by using them as indicator species. For example, because certain salmonids such as bull trout (*Salvelinus confluentus*) require exceptionally cold, clean, well-oxygenated water, biologists in the Pacific Northwest now use them as a surrogate to gauge the health of aquatic ecosystems.

Economic

For fishing guides and outfitters and other businesses that benefit from angling-related tourism, one of the most compelling reasons for preserving native trout is that they generate millions of dollars for local economies. For example, a study of the potential economic impacts of the non-native lake trout invasion in Yellowstone Lake revealed that the cutthroat fishery in the Lake and adjoining Yellowstone River was worth $36 million annually to communities like West Yellowstone and Gardiner, Montana (Varley and Schullery 1995). If the lake’s cutthroat fishery were to be replaced with a lake trout fishery, the latter would likely generate considerably less income because lake trout would be far fewer in number, more difficult to catch, and require boats to access them.

Similarly, biologists point out that one of the main reasons why anglers from around the world are drawn to the South Fork Snake River in eastern Idaho is because it harbors a healthy population of large Yellowstone cutthroat trout, which are quick to rise to dry flies. If the cutthroat population were to be displaced by non-native rainbow trout, as is the current trend, overall catch rates would decline, which could result in lower angler satisfaction and fewer angler visits.

Cultural

Another reason why conserving native trout should be a top management priority is because, just like historic buildings, unique landscapes, and cultural heritage, they help define the places where we live. There is a reason why every state in the western U.S. has designated either a native cutthroat trout, native rainbow trout, or native salmon as their official state fish – because they help define what makes those places special. If we allow the few remaining populations of native Colorado River cutthroat trout to disappear from Wyoming, or let the last remaining populations of westslope cutthroat trout vanish from Montana east of the Continental Divide, we compromise part of our unique western identity and become more like other regions of the country where wildness is no longer a part of the landscape.

Perhaps no sub-group of people within our society treats native fish as such an important part of their cultural identity as Native Americans in the Pacific Northwest. When asked by a reporter how important it was to keep wild salmon from going extinct in the Columbia River, Antone Minthorn, chair of the Confederated Tribes of the Umatilla Indian Reservation in Oregon, replied: “How can I tell you what salmon are worth to me? The salmon are who I am.”

Moral/Spiritual

A final reason why native fish should be preserved is that they have an inherent right to exist. In his 1978 book, *The Arrogance of Humanism*, Professor David Ehrenfeld writes that species should be conserved “because they exist and because this existence is itself but the present expression of a continuing historical process of immense antiquity and majesty (Ehrenfeld 1978).” Among Native Americans in the Pacific Northwest, there could be no higher justification for saving native fish than for spiritual reasons. In the book, *Salmon and His People*, Nez Perce tribal member Jamie Pinkham writes: “Fish provide us with both physical and spiritual sustenance. Other cultures seem unable to recognize how those two concepts go hand in hand. Instead, they see them as separate: traditional beliefs on one side, science on the other. For Indian people those concepts have never been separate. Our fate and the fate of fish are linked (Landeen and Pinkham 1999).”

Conclusion

Regardless of which justification or combination of justifications one uses to argue for native fish conservation, the questions remains, what must we as scientists, anglers, and conservationists do to ensure that native trout not only persist, but are also restored to major portions of their historic range throughout the West? I believe we need to do three things. First, we must permanently protect in a network of native fish sanctuaries those core habitats where healthy metapopulations of native trout persist. This protection should come in two forms. First, we must ensure that the aquatic habitats that harbor these native fish populations are not further degraded by dams, roadbuilding, logging, mining, grazing, energy development, or other potentially damaging activities. And second, we must implement harvest regulations and stocking practices that are designed to minimize adverse impacts to native fish.

The idea of creating native fish sanctuaries is not a new one. In 1892, U.S. President Benjamin Harrison created the Afognak Forest and Fish Culture Reserve on Afognak Island in Alaska with the intention of permanently protecting Pacific salmon runs (Rahr et al. 1998). Unfortunately, the concept never caught on, although federal Wilderness and Wild and Scenic River designations have created de facto native fish sanctuaries in places like the Middle Fork Salmon River drainage in central Idaho and the North Fork of the John Day River drainage in Oregon. An example of a place in the GYE that would make an ideal native cutthroat trout sanctuary is the headwaters of the Snake River drainage in northwest Wyoming.

But if we truly want to preserve native trout in the West as more than just museum pieces, it will not be enough to simply create sanctuaries in existing native fish strongholds. We must go one step further and create new native fish strongholds in places where remnant native fish populations co-exist with non-native fish in compromised environments. A good example of such a place in the GYE is the Upper Henrys Fork drainage from Henrys Lake downstream to Island Park Reservoir. Historically, Yellowstone cutthroat were the only trout native to the Henrys Fork drainage. Today, they have been displaced by introduced rainbow trout virtually everywhere in the drainage except Henrys Lake, which to this day is heavily stocked with rainbow/cutthroat hybrids and brook trout. While creating a native cutthroat sanctuary in the Upper Henrys Fork would pose an exceedingly difficult challenge in terms of eliminating non-native fish, restoring degraded habitat, and garnering public support, it is just the sort of action that will be required to conserve native trout across large expanses of the landscape.

Finally, we must do everything we can to protect isolated native fish populations that possess unique genetic characteristics or live at the geographic or environmental fringes of their range. There are at least two good reasons for doing this. The first is that these populations contribute to the overall genetic diversity of a species, which improves its chances of persisting over time. For example, some native redband trout in the Great Basin have adapted to survive in streams and lakes that routinely reach temperatures of 26 degrees Celsius or higher in summer, an environment in which virtually no other salmonids could survive (Behnke 1992). If climate predictions are correct and the West continues to get warmer and drier, these desert redbands may be the only form of inland rainbow trout that are still around 100 years from now. A second reason to preserve isolated native fish populations is that they serve as a hedge bet in the event that non-native trout disappear from other areas due to unforeseen future events. For instance, if a new disease were to selectively wipe out all the non-native rainbow trout in Montana’s Madison River, biologists theoretically could re-seed the river with native westslope cutthroat trout that have a resistance to the disease.

Ultimately, society as a whole is unlikely to support native fish protection and restoration until we as fisheries managers, anglers, and conservationists first convince ourselves that it is the right thing to do, which has yet to fully happen as demonstrated by the need for this panel discussion. As the acclaimed outdoor writer Ted Williams wrote in a recent issue of *Audubon*: “Managers need to quit trying to figure out what native trout can do for us and attempt a new approach. Maybe it starts with a simple statement that these fish are priceless works of art that need to be protected for themselves, for the species that need them, and for people who cherish them for what they are and because they are (Williams 2002).” Perhaps when that paradigm shift occurs we can begin to think big enough, act boldly enough, and move swiftly enough to accomplish the daunting task before us.

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Partnerships in Trout and Native Fish Management—an Australian Case Study

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ABSTRACT—Australia's recreational fisheries include trout introduced in the 19th century. In the State of Victoria, trout angling has benefited from regulation of major streams such as the Goulburn River. River regulation has impacted on native species and there is tension between trout and native fish advocates. Fisheries managers need to identify common objectives aligned to both trout anglers' wishes and the community's desire for conservation of threatened native species while facilitating the economic and social benefits that trout bring. The conflict can be dealt with by fisheries management planning conducted through independent co-management structures including fish stocking based on agreed translocation principles. A model 5-year inland fishery management plan for Victoria's Goulburn River Basin has exposed trout angling advocates to the needs of native fish identified in the State's river health management practices. A Partnership Committee has been established to oversee implementation. The committee features direct co-operation with wider stakeholder groups to ensure balanced outcomes for both trout and native fish. Where conflict exists between trout and native fish advocates the focus of recreational management must be on establishing partnerships that positively influence trout anglers to support biodiversity and water and catchment management programs that improve the quality of all fisheries.

Introduction

The impact of trout on native fish stocks in Australia is still not fully understood and, as a consequence, is controversial. There is a perception that management must favor either trout or native fish. In practice, the task of fisheries management is to achieve balanced outcomes in the face of changing habitat and native fish stock status and within a complex framework of dynamic Government policies on resource utilization and socio and economic objectives.

A focus area for the 'conflict' is the Goulburn River in Northeast Victoria. The upper catchment (Figure 1) of the Goulburn is 2% of the surface area of Australia's Murray Darling Basin and 8% of the water resources (UGWP 1998) including Victoria's principal irrigation supply dam, the 3,390,000 megalitre capacity Lake Eildon. Much of the catchment is seen as a degraded native fish habitat and there is strong public pressure for rehabilitation of native fish stocks within it.

It is also Victoria's premier trout fishery with eleven wild trout (i.e., self-sustaining) stream fisheries and a number of put and take fisheries such as the Eildon Pondage.

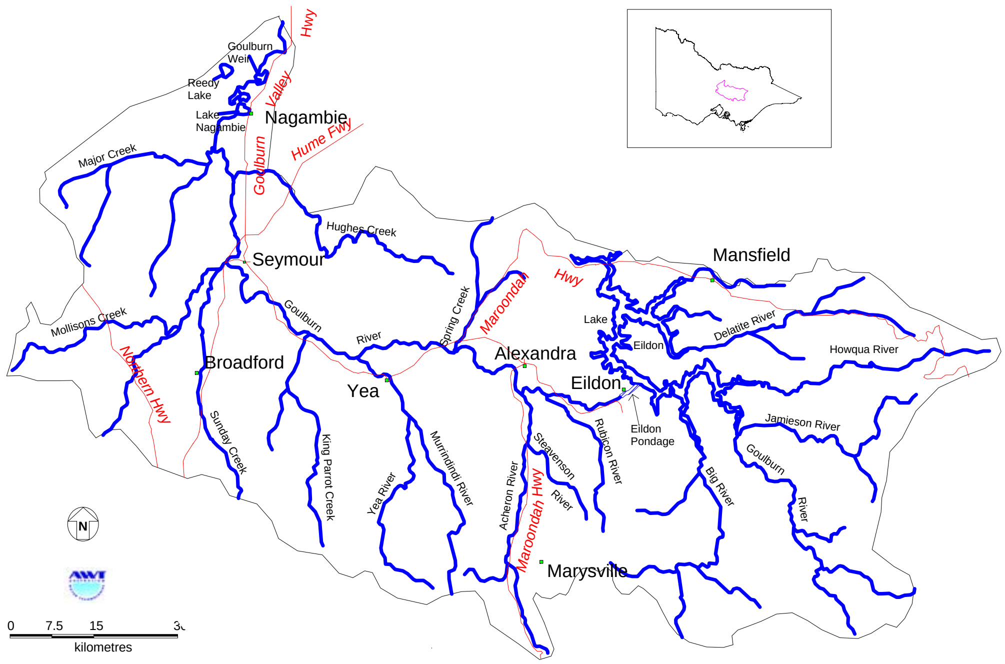

Figure 1. Goulburn River Catchment

Victoria's Recreational Fisheries

Australia has a mixed range of freshwater finfish species that anglers target including the native *Maccullochella peeli* (Murray cod), *Macquaria ambigua* (golden perch), *Bidyanus bidyanus* (silver perch), *Tandanus tandanus* (freshwater catfish) and the introduced *Salmo trutta* (brown trout) and *Oncorynchus mykiss* (rainbow trout). Nearly 550,000 Victorians fish annually as part of their recreational pursuits, with a significant portion of effort occurring on inland waters (43%). This is significantly more than the national average (20%) (NRIFS 2003).

Trout

Fisheries Victoria currently assume responsibility for the bulk of trout stocking. In the last 40 years the number of trout released annually has decreased from about 2 million to between 330,000 and 430,000. The number of waters has similarly decreased from over 180 (mean for 1960-64) to around 100 in 2002. These reductions recognize that many streams now support wild trout populations (Winstanley 2001). Trout still account for 70% of Fisheries Victoria's annual stocking costs.

Native fish

In comparison with trout, native fish numbers have been severely impacted in Australia post-European settlement (MDBC 2003). The first State government funded stockings of hatchery-produced Murray cod in Victorian public waters occurred in 1980/81 when 6,000 juveniles were released. Since then the number of Murray cod released annually has steadily increased with the Department of Primary Industries stocking the bulk of Murray cod into public waters (Winstanley 2001).

Table 1. Trout / Salmon and Native fish stocking between 1993 and 2003

Year	Trout / Salmon	Native fish	Totals
1993	400,247	193,742	**593,989**
1994	515,004	661,907	**1,176,911**
1995	584,921	728,429	**1,313,350**
1996	406,252	606,820	**1,013,072**
1997	450,745	670,651	**1,121,396**
1998	378,717	720,080	**1,098,797**
1999	340,150	775,331	**1,115,481**
2000	386,175	575,638	**961,813**
2001	333,587	690,170	**1,023,757**
2002	329,814	970,875	**1,300,689**
2003	331,951	621,060	**953,011**
Total	**4,457,563**	**7,214,703**	**11,672,266**

Source Department of Primary Industries data

River regulation impact on native species

The provision of water for irrigation has reduced total flows and significantly changed the seasonal flow patterns and flood frequencies in almost all of Victoria's northern flowing rivers. The cold water released from major dams during Spring reduces spawning opportunities and survival rates for native fish.

Tension between Trout and Native Fish Advocates

Conservation of endangered species

There are ongoing endeavors to restore the native fisheries. For example in Australia's Native Fish Strategy for the Murray Darling Basin, one aim is to rehabilitate native fish species to 60% of their pre-European populations over the next 50 years (MDBC 2003).

The strategy recognizes that recreational fishing stakeholders ‘should be encouraged’ to play a major role in rehabilitating native fish populations. It doesn't however identify the public value of introduced recreational fish species and some of the proposed actions have the potential to adversely affect wild trout angling and to alienate anglers and tourism interests that might otherwise support the strategy.

Fisheries Victoria thus sets targets for rehabilitation of native fish in the context of obligations to preserve established trout fisheries where possible. (Victoria has several rivers protected under the Heritage *Rivers Act* where the river's value as a trout fishery was identified in granting the heritage status). In doing so it also recognizes it has obligations to manage actions that threaten native fish which are listed as threatened under the *Flora and Fauna Guarantee Act, 1988.*

Economic and Social Benefits of Trout Fisheries

The trout fishery is unique in the State in that it is managed purely for the social and economic benefits that it provides to the community (Winstanley 2001). Anglers' spending on fishing tackle, bait, licenses, boats, fuel, transport, meals, accommodation and fishing guides provides significant input to regional economies. In 1997, Northeast Victoria generated $AUD 118.8 million (or 11.4%) of the gross angling expenditure on recreational fishing in Victoria and attracted 17.6% of all angling fishing activity in the State (FEIS 1997). Brown and rainbow trout are the most popular species sought in the region being the preferred catch for over 70% of anglers.

Discussion

Managing the Fisheries

A key feature of recent developments in Australian fisheries management has been the acceptance of a broad range of rationales and justifications. These include increasing community awareness of the need for conservation and sustainable use of finite fish resources and the magnitude and socio-economic significance of recreational fishing activities (Winstanley 2001).

Native fish and river health plans

Victoria has an integrated environmental management multiplan framework (Figure 2) encompassing river health, water entitlements, streamflow management and biodiversity maintenance (NRE 1997). It sets the directions for all the major management functions in rivers and their associated floodplains and wetlands, and

- identifies environmental, recreational, cultural, social and economic assets for the State's waters, the current condition of the asset vs. community values (including recreational fishing);
- identifies processes threatening these values and the severity of the risk involved;
- identifies opportunities for restoration of degraded values and requirements for restoration;
- sets broad priorities for action and the key specific actions required.

Issues are integrated and articulated as river health objectives within each catchment. This approach delivers many of the desired outcomes that lead to rehabilitated native fish populations.

Goulburn Eildon Fishery Management Plan

This framework introduced a new complexity into the development and introduction of Victoria's first inland Fishery Management Plan. Within it, Fisheries Victoria's managers set out to encourage maximization of the opportunities provided by **both** wild trout and the native fish resources. Our objectives included:

- provision of a wide variety of fishing experiences with year-round fishing opportunities for both native and introduced species;
- development of both fisheries to their full sustainable potential;
- promotion of improvements in relation to a wide range of threatening processes; and
- involvement of all stakeholders in the fisheries management process.

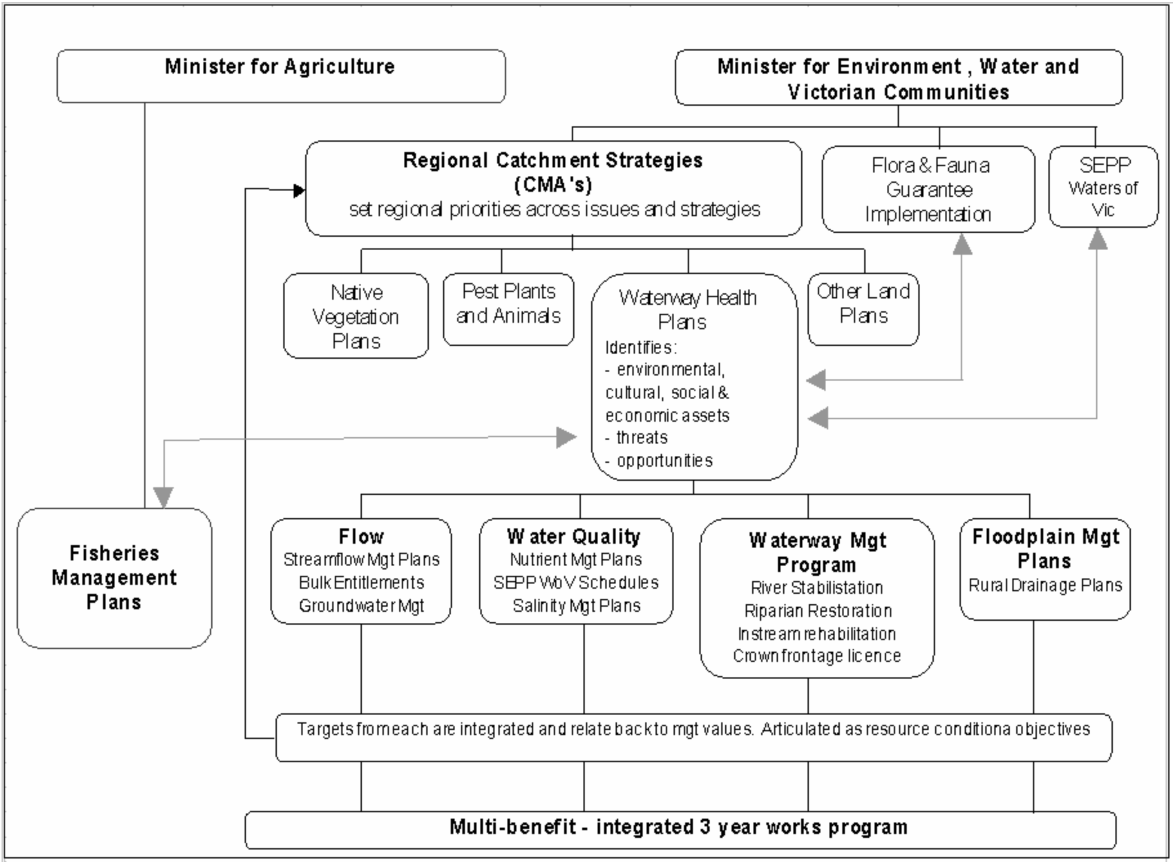

Figure 2. Victoria's Environmental Planning framework

It became clear quite early in the process that the environmental planning framework and its emphasis on river health reinforced trout anglers' views that Government favored native fish over trout. On the other hand water management practices led the community to the belief that trout were favored over native fish. To counter this conflict a stepped methodology for the planning process was developed, including: -

1. a discussion paper to expose the issues and management objectives and strategies and
2. public meetings in local population centers for confirmation of the issues and feedback on the management options

This process developed stakeholder recognition that two fundamental factors determine what is possible in terms of fisheries management in the Goulburn River, the irrigation water release practices and the water temperature regime that results during the irrigation season. This realization during the phased consultation process allowed balanced strategies to be developed.

Co-management

Fishery Management Plans are developed under the *Fisheries Act, 1995*. The Act establishes an independent Fisheries Co-Management Council comprised of industry stakeholders outside Government to drive the management process.

Co-management aims to bring all stakeholder groups together and create a shared vision for the future of Victorian fisheries. It plays a pivotal role in enabling communication and consensus building within the planning process and in achieving balanced outcomes that provide for both trout and native recreational fisheries.

Implementation Partnerships

In striving to work through the trout v native fish conflict, the strengthening of partnerships is critical to the credibility of the commitments made during plan formulation.

At a broad level, Victorian fisheries management arrangements are led by the Department of Primary Industries (Fisheries Victoria and Northern Region). A sister agency, the Department of Sustainability and Environment, in partnership with Catchment Management Authorities and Water Management agencies coordinate inputs to environment and biodiversity plans and programs. A coalition of these government stakeholders and representatives of trout anglers, water managers and others meet regularly to integrate actions to implement the Fishery Management Plan into the individual stakeholder's activities. This coalition reports annually against performance measures included in the fishery management plan.

Associated Stocking Principles

The dynamic planning process has also been a catalyst in managing wider conflict in respect to fish stocking generally.

A new stocking policy framework

The release of any fish species into rivers and streams now occurs within strict guidelines (DPI 2003). The risks of stocking are determined to be either minimal, acceptable or manageable and proposed stockings that do not conform to the guidelines are required to undergo a risk-assessment funded by the proponent (Figure 3).

Table 2. Summary of fish stocking environmental risks and proposed management response

Risk Category	Description	Risk Management Response
Environmental/ ecological risks	Genetic shift in wild populations and hybridization	Appropriate sourcing of brood stock Maintaining sufficient pools of brood stock
	Establishment of feral populations	No stocking where there is documented risk to endangered species.
	Translocation of associated species	Surveillance and monitoring programs Stock certification Treatment of transport vehicle and medium
	Interaction with native species and/or habitat alteration	Limit the number of species to be stocked; Stock only within the natural range of the proposed species or in waters where the proposed species has been recently stocked (since 1995); or No stocking where there is documented risk to endangered species.

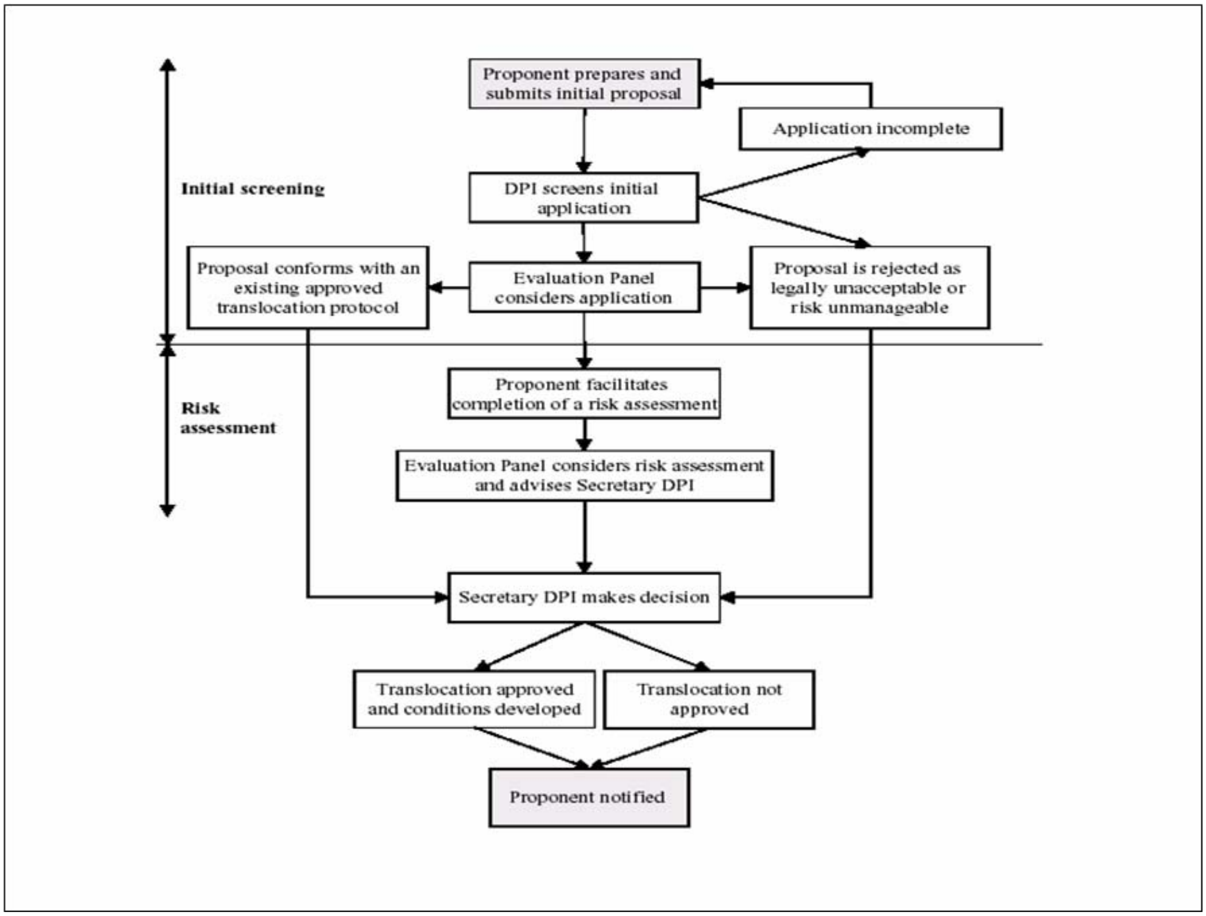

Figure 3. Stocking Risk Assessment

Balanced Outcomes

Examples of specific outcomes within the Goulburn catchment that have benefited both native and trout anglers (and reduced tension between the two groups) since the coordinated approach commenced include:

Identified habitat preferences of large trout and golden perch in impoundments

Radio tracking of both species has determined habitat associations that have opened up extra dimensions in the Lake Eildon recreational fishery assisting anglers to better target golden perch.

Developed knowledge of trout movement in the Goulburn River

Radio tags have been used to determine the habitat used by catchable size brown trout under high and low flow conditions in the Goulburn River assisting anglers to better target trout.

Fine-tuned recreational fishing impact on endangered wild native fish species.

A joint whole of government evaluation has concluded that anglers have no apparent significant impact on threatened native species (e.g. Murray cod and Golden Perch) within the Goulburn catchment.

Protection of dead timber as fish habitat

Standing and fallen dead timber has been protected in Lake Eildon to secure important fish habitat for native species such as Murray Cod.

Work yet to be done

A principal issue yet to be resolved is the possibility of engineering a rise in the temperature of the water released into the Goulburn River from Lake Eildon and modifying water delivery practices to improve the status of native fish within this river system.

Depending on what delivery changes were made and how much the water temperature was changed, at what time of the year and for how long and what engineering and delivery point solutions were used, both native and introduced trout and all anglers could potentially benefit.

Conclusions

Balanced freshwater fishery management in Australia is demonstrating that trout fishery management can limit impacts on native species.

A focus on establishing partnerships positively influences both trout and native species anglers to support biodiversity, water, and catchment management programs that improve the quality of all fisheries.

The major pay-off will be growing community confidence that maintaining a productive wild trout fishery does not in itself threaten native fish conservation in Australia.

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Managing the Threat Posed by Lake Trout to the Lake Pend Oreille, Idaho, Fishery

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ABSTRACT—Non-native lake trout have had significant negative impacts on native bull trout and other popular sport fisheries in lakes in the northern Rockies. Evidence of a rapidly expanding lake trout population and declining kokanee population in Lake Pend Oreille (LPO), Idaho, prompted significant fishing regulation changes in 2000. Two years of predator reduction efforts and no improvement in the kokanee population prompted an intensive angler involvement program to define and implement socially acceptable means of predator reduction. A Citizens Advisory Committee (CAC) recommended establishment of a commercial rod-and-reel fishery for lake trout. The CAC also approved the experimental use of deep water trap nets similar to those used on Lake Michigan to commercially harvest lake whitefish. Funding was obtained to build and fish nine trap nets for two 6-month assessments in LPO. Opposition to the use of trap nets surfaced in a petition with 1,820 signatures just prior to the fishery commencing. Evaluation of commercial trap nets was implemented in the fall of 2003, with 1,183 lake trout caught, tagged and released for a population estimate of 6,376 fish > 52 cm, but no lake trout were harvested. Continued opposition to the use of trap nets prompted the Department to postpone the second season of the trap net evaluation.

Introduction

Lake trout *Salvelinus namaycush* have caused increasing concerns for fishery managers in lacustrine systems in the northern Rockies due to their ability to replace native fish populations and popular sport fisheries. Donald and Alger (1993) documented the displacement of native bull trout *Salvelinus confluentus* by introduced lake trout over much of their range. More recently, Fredenberg (2002) demonstrated how lake trout expansion has had a substantial detrimental impact on bull trout populations in four Glacier National Park lakes. Illegally introduced nonnative lake trout into Yellowstone Lake in Yellowstone National Park, combined with the presence of the invasive exotic parasite *Mxyobolus cerebralis* (the causative agent of whirling disease) has resulted in a significant decline to Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* populations (Bigelow et. al. 2003) with potential ecosystem-wide consequences. Priest Lake, Idaho, is an example where lake trout increased and finally dominated the system causing the collapse of a popular kokanee *Oncorhynchus nerka* fishery and the near extirpation of native bull trout and westslope cutthroat trout *Oncorhynchus clarki lewisi* (Mauser and Ellis 1985).

Lake Pend Oreille (LPO), the largest (38,042 ha), deepest (351 m) natural lake in Idaho (Figure 1), currently supports one of the strongest adfluvial bull trout populations in the northern Rockies despite the presence of lake trout. Lake trout were introduced into LPO in the 1920s by the U. S. Fish Commission, but they have not been a significant part of the fishery until relatively recently. Bull trout redd counts in 19 tributary streams to LPO have ranged from 412 to 881 between 1983 and 2003 and the population is currently believed to be stable (Downs and Jakubowski 2002). LPO also supports a popular sport fishery for introduced trophy rainbow trout *Oncorhynchus mykiss* and kokanee.

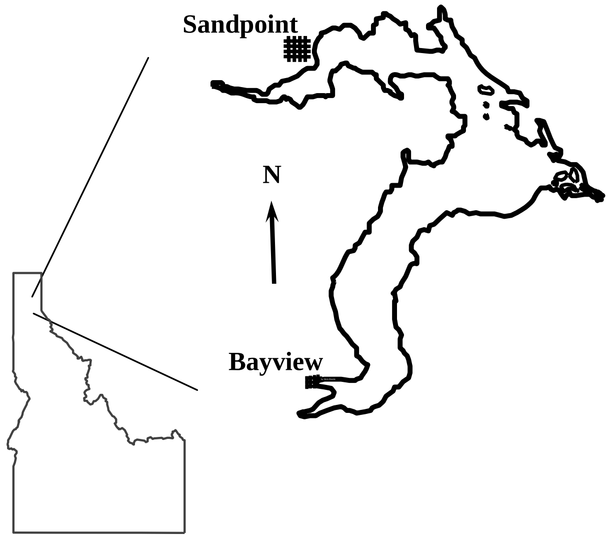

Figure 1. Lake Pend Oreille, Idaho.

Concerns that lake trout were increasing in LPO came to light in the late 1990s. Idaho Department of Fish and Game (IDFG) creel census data up through1991 (Table 1) indicated lake trout catches were rare despite their presence in the lake since the 1920s. A 1998 mark/recapture population estimate of only 1,792 lake trout > 43 cm indicated a relatively small population (Vidergar 2000). However, rainbow trout anglers were reporting increasing incidental catches of lake trout during this same time. The impact of a large flood event in 1997 resulted in a severe decline in the kokanee population and concerns over a predator induced kokanee collapse prompted significant changes to fishing regulations in 2000. The kokanee fishery was closed, the rainbow trout limit was liberalized from two fish over 50 cm to six fish any size and the limit on lake trout was removed completely. A year round creel census was conducted in 2000 to monitor predator reduction. The lake trout catch and harvest estimate during the 2000 creel was 6,025 and 4,707, respectively, despite lake trout anglers comprising only 8% of the total effort (Table 1). The difference between the population estimate of 1,792 fish in 1998 and harvest estimate of 4,700 lake trout in 2000 indicated a rapidly expanding population.

By 2002, little progress had been made toward kokanee recovery despite two years of encouraging anglers to harvest rainbow trout and lake trout. IDFG launched an intensive angler involvement program to define and implement socially acceptable means of predator reduction.

Table 1. Comparison of the 2000 angler creel survey results with past creel surveys on Lake Pend Oreille, Idaho.

	Creel Survey Year				
Parameter	**1953**	**1978**	**1985**	**1991**	**2000**
Rod hours	523,000	226,453	179,229	460,679	363,974
Angler hours	523,000	226,453	179,229	460,679	232,200
Angler days	100,000	48,470	36,446	90,000	33,140
Interviewed anglers	--	5,283	--	7,382	6,443
Lake trout					
Harvest	0	0	0	*	4,707
Percent of total	--	--	--	4%	8%
Rainbow trout					
Harvest	3,200	6,878	6,100	2,261	8,827
Percent of total	--	39%	60%	55%	86%
Bull trout					
Harvest	5,000	1,469	915	1,723	closed
Kokanee					
Harvest	1,336,000	167,640	71,275	227,140	closed

**43 fish observed in creel during 1991, but no harvest estimate was made.*

Methods

Citizens Advisory Committee Process

The Department sponsored a half-day public workshop on March 23, 2002, to discuss the LPO fishery. The objectives of the workshop were to:

- Inform the public about the declining status of the kokanee population in LPO.
- Assess community perceptions regarding why recent changes in harvest rules have not caused kokanee survival to increase.
- Identify ways to develop community support for reducing the predator population in LPO.
- Explore ideas on how the IDFG and community can build trust and communication.
- Seek community input on the desirability of convening a Citizens' Advisory Committee (CAC) to explore ways to integrate community interests with predator and kokanee population objectives.

Formation of the CAC was developed through input from the public obtained during the March Fishery Workshop. The following question was asked to workshop participants:

The Department may select representatives from your community to expand on some of the ideas that you developed today. What personal qualities,

***values, or other factors would you like to see among the people that are asked to represent you on a Citizens' Advisory Committee**?*

Participants at the Workshop provided the following input regarding formation of the CAC: In addition to traditional stakeholders such as fishermen, fishing guides, and marina operators, the workshop participants felt that CAC members should also represent the range of interests within the broader community. This should include women, non-fishermen, community decision makers, business owners, Chamber of Commerce representatives, people that understand local economics, among others. CAC members should have strong leadership and communication skills, be open-minded, knowledgeable, inquisitive, persistent, and have the time needed to commit to the process. The workshop participants felt that CAC members should explore ways to keep the community informed.

Nine participants were selected to represent various local interests in the LPO fishery including representatives of two organized fishing clubs, two unaffiliated anglers, one charter boat captain, a local taxidermist, a marina operator, a life-long resident and a Chamber of Commerce president. Group size was limited to nine individuals to make consensus decision making more realistic.

The CAC worked under an operating Charter developed and approved by IDFG and adopted by the CAC. The Charter describes the CAC sponsors, members, budget source, background information, objectives, side-boards, products, sponsor commitments, and measures of success (CAC Final Report 2002). Seven meetings were held between May 10 and September 17, 2002. A final public workshop was held on October 23, 2002 to present recommendations and findings.

The Department asked the CAC to explore three questions:

1. How can anglers, the community, and the Department work together to reduce the predator population (i.e., rainbow and lake trout) in LPO, so we can prevent a kokanee collapse and begin recovery of the kokanee and trophy rainbow trout fishery?
2. How can the Department Panhandle Region and the LPO community communicate effectively in the future?
3. What other important issues were raised in the public workshop on March 23, 2002, that the Department could address efficiently using limited time, manpower, and funding?

The CAC developed five primary recommendations, which were distinguished as critical actions that the Department and/or local communities should consider and implement immediately. Two recommendations specifically dealt with lake trout:

1. Aggressively support and promote a "catch/keep" philosophy for rainbow and lake trout on LPO.
2. Support the establishment of a commercial fishery for lake trout on LPO.

Implementation of the CAC recommendations for lake trout and the biological and social response to implementation are the focus of the results section.

Results

Biological Actions Implemented

Commercial lake trout fishery established—As a result of the CAC recommendation, and public support at the October 23, 2002 final CAC workshop, the Idaho Fish and Game Commission approved changes to the commercial fishing rules (IDAPA 13.01.02) during their December 2002 regular meeting. The changes allowed commercial harvest of lake trout in LPO, allowed rod-and-reel as an approved commercial harvest method and allowed commercial harvesting with experimental gear such as trap nets. The CAC requested, and IDFG established, a limited entry of no more than 10 commercial licenses. An application process was established, with 13 applicants screened and 10 licenses issued in March 2003.

Commercial licenses were issued on a July 1-June 30 year. By July 1, 2003, only seven licenses were active. By July 1, 2004, only three commercial rod-and-reel lake trout licenses had been renewed. Commercial rod-and-reel anglers reported harvesting 522 lake trout and purchasing another 126 from sport anglers in the 15 months the program had been active. Sport anglers are allowed to sell up to $500 worth of lake trout annually to a commercial license holder.

Use of Trap Nets—The CAC also debated at length the experimental use of deep water trap nets as means of catching and potentially harvesting lake trout. Trap nets have been used for over 100 years in the Great Lakes to commercially harvest lake whitefish *Coregonus clupeaformis*, with lake trout also being vulnerable to this gear.

Funding for the trap net assessment ($329,400 annually for two years) was obtained through Avista Corporation, a private utility, through the Clark Fork Settlement Agreement. Harbor Fisheries, Inc., of Bailey's Harbor, Wisconsin, fished nine nets in 13 locations from October 2003 through March 2004 yielding a population estimate of 6,376 lake trout > 52 cm (Peterson and Maiolie 2004). The intent of the project was to begin to harvest lake trout once the population estimate was complete.

Social Response to Implementation Actions

Just prior to the deployment of the trap nets, a group calling themselves Citizens Against Netting Fish in Lake Pend O'Reille (CANFILPO) gathered a reported 1,820 signatures (only 1,427 were made available) on a petition against the trap netting and a letter was sent to the Idaho Governor's office, all State and Congressional representatives, as well as the Federal Energy Regulatory Commission requesting the revocation of Avista's new hydro license obtained under the Clark Fork Settlement Agreement for Cabinet Gorge and Noxon dams. CANFILPO wrote weekly letters to the editors of local and regional newspapers over an eight-month period and placed posters (Figure 2) over the information signs IDFG put out to notify anglers where trap nets were located.

The perception of public discontent resulted in changes being made to the commercial fishing rules for lake trout during the winter of 2004. Trap nets could no longer be used to harvest fish for commercial sale even though no harvest of lake trout by trap nets had occurred. A facilitated public meeting was held in February 2004 to provide information about overall fishery recovery efforts, to describe the trap net fishery results and allow public input on any topic. Of the 105 participants who registered, over 90% responded positively to a follow-up survey about the meeting information and input opportunity. CANFILPO voiced their displeasure through the survey, additional letters to the editor and comments to elected officials.

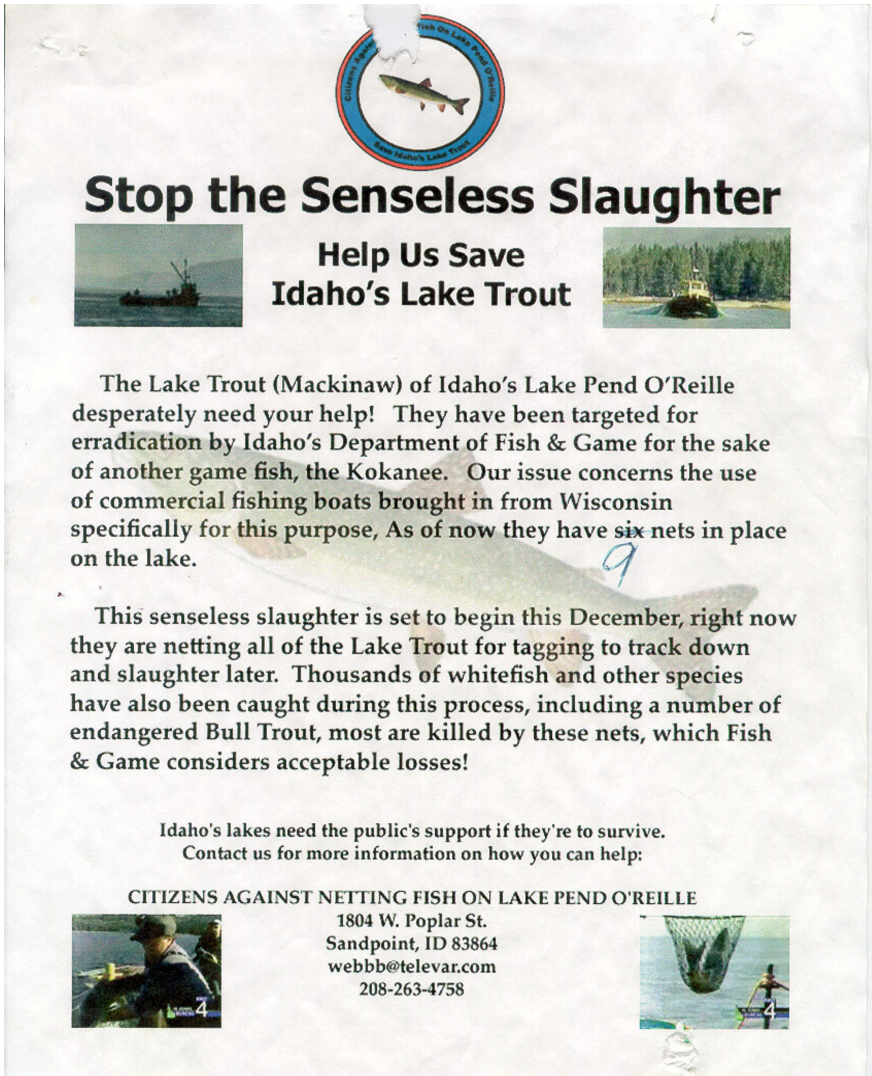

Figure 2. Poster used to protest the deep water trap net fishery for lake trout in Lake Pend Oreille, Idaho, during the winter of 2003-2004.

Continued concerns over public perceptions about the use of trap nets as well as the need to address short-term biological questions resulted in the suspension of the trap net evaluation for the winter of 2004-2005. Plans call for a resumption of the evaluation in September 2005, but trap nets will be used to redo the lake trout population estimate and gather population dynamics information on the lake whitefish population.

Emphasis during the next year will focus on evaluating how effective anglers can be at harvesting lake trout, determining lake of origin (LPO or Flathead Lake) by microchemistry analysis to better define recruitment, modeling basic population dynamics information for LPO lake trout, and conduct an angler preference survey.

Discussion

It is clear that lake trout pose a serious risk to native fish populations as well as popular sport fisheries in LPO (Panhandle Bull Trout Technical Advisory Team 1998). What is not clear is how much risk 6,400 lake trout currently pose and how the population is changing. Anglers as well as fishery managers did not react in time to keep lake trout from collapsing other fisheries. IDFG knew that predator reduction in general and consideration of removal of lake trout by trap nets would be controversial. There is now uncertainty about the level of pubic support for lake trout management actions.

The CAC process was perceived by IDFG to be a legitimate attempt to involve broad based stakeholder groups to better define what was socially acceptable in terms of predator management to recover kokanee and preserve native bull trout and a popular trophy rainbow trout fishery. Involved stakeholders did not consider CANFILPO legitimate or representative and therefore did not consider their complaints a serious threat. Of the 1,427 petition signatures made available for review, 382, or 27% were licensed anglers in 2003, suggesting many individuals signing the petition were relatively uninformed about the LPO fishery. Other anglers who supported fishery recovery efforts did not support the use of nets, so they did not counter the claims of CANFILPO. Regardless, it is clear that missing a key stakeholder group in the CAC process caused much of the effort to be ineffective.

Commercial fisheries for lake trout were a popular idea expressed at the March Workshop and further discussed and recommended by the CAC. However, the angling public is convinced that anglers can play a significant role and they are uncertain about commercial net fisheries. The results of 15 months of commercial rod-and-reel fishery harvest are not encouraging with a total of only 522 lake trout harvested and another 126 purchased from sport anglers. Lack of a suitable market for lake trout and strict Food and Drug Administration (FDA) regulations for fish handling and processing limited participation in the fishery. One commercial license holder built a FDA approved smoking facility and was marketing smoked lake trout on a limited basis.

An evaluation of angler exploitation of trap net tagged lake trout during the annual spring fishing derby indicated a 12% exploitation rate during a time frame when approximately half of the annual angling effort occurs. Even if this value is increased to account for non-reporting bias, it suggests controlling lake trout through sport fishing alone may be difficult. Healey (1978) indicated that lake trout could sustain a combined annual mortality rate (natural mortality and exploitation) of about 50% and still remain viable. IDFG will be evaluating angler harvest effectiveness over the next year by shifting some of the funding from the trap net evaluation to derbies or other incentive programs and measuring harvested fish against the trap net population estimate. Another trap net population estimate in 2005-2006 will provide an additional measure of angler harvest potential.

The first season of the trap net evaluation demonstrated the usefulness of commercial gear for research, but large trap nets alone may not be a suitable way to suppress the lake trout population (Peterson and Maiolie 2004). However, it may be possible to improve trap net effectiveness in LPO. Trap net fishing location and timing were modified in 2003-2004 to address sport fishery concerns. Future plans would evaluate times of the year when catch rates for trap nets were higher (September and April) and suspended nets would be fished in an attempt to sample the steep shorelines of LPO.

Lake trout have not been a preferred species in LPO, so it was surprising to see the reaction generated by CANFILPO. Lake trout have been managed against in LPO with liberal bag limits since 1992. Past creel census information indicated that participation in the lake trout fishery was minimal, with the vast majority of anglers preferring kokanee and trophy rainbow trout (Table 1). The relatively recent increase in lake trout, combined with regulation changes to restore the kokanee population, have given the lake trout fishery a boost. Some consumptive oriented anglers have shifted from kokanee to lake trout due to the kokanee fishery closure and competitive trophy anglers have done better in recent derbies focusing on lake trout instead of rainbow trout. Still, a limited creel census during the spring derby in 2004 indicated that only 12% of the anglers were fishing for lake trout despite better catch rates, bigger fish and equal prize money to rainbow trout. An independently conducted angler preference survey is needed to assess what role the lake trout fishery plays in relation to native fisheries for bull trout and cutthroat trout and popular sport fisheries for kokanee and trophy rainbow trout. It will be impossible to please everyone.

The aggressive action taken by IDFG to address the lake trout threat in LPO was viewed as necessary by the apparent rapid increase in lake trout indicated by the 2000 creel census. Fortunately in the near term, the trap net evaluation demonstrated that lake trout were not as abundant as feared, but still higher than 1998. There are still important unanswered biological questions to pursue, including quantifying recruitment, identifying recruitment sources (natural from LPO or downstream drift from Flathead Lake), the predatory impact of lake trout on other species, and whether human induced mortality on lake trout can be elevated to a point where lake trout numbers can be controlled. Just as important, social concerns about lake trout control must be addressed before we can move forward with fishery recovery efforts.

Acknowledgements

The Idaho Department of Fish and Game wishes to extend their deepest appreciation and gratitude to the nine members of the Lake Pend Oreille Citizens' Advisory Committee – Chairman Hobart Jenkins, Don Banning, Roger Best, Stuart Blockoff, John Broadsword, Bill Friedmann, Ken Hayes, Linda Olson and Dean Press. These nine citizens took time out of their busy lives to try and help solve the complex problems associated with saving the unique fishery of Lake Pend Oreille. Funding for the trap net fishery was provide by Avista Corp. Crew members of Harbor Fisheries, Inc. Dennis Hickey, Steve Warwick, Todd Stuth, Ted Eggebraton and Jack Toung did a tremendous job of dealing with a unique biological and social challenge. Mike Peterson, Melo Maiolie and other IDFG personnel assisted with data collection and interpretation.

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Balancing Bonneville Cutthroat Trout with Non-Native Salmonids in Great Basin National Park

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ABSTRACT— Bonneville cutthroat trout, the only native trout in Great Basin National Park, have been reintroduced into several streams in and near the park following their extirpation at the beginning of the century. At the same time, Great Basin NP has emphasized the availability of a recreational fishery for non-native salmonids in other park streams, using tools such as the park newspaper, resource management newsletter, website, and an interagency brochure distributed throughout the area. The response to this two-pronged approach has largely been positive, with the greatest amount of conflict from the state, which has a different management philosophy. The cessation of non-native stocking when the park was established in 1986 caused some locals to mourn the loss of the big trophy fish they remember catching in previous years. Population surveys reveal that size of brown trout has indeed decreased in some streams while fish abundance has increased. The park has responded to these concerns using data that show that the density of Bonneville cutthroat trout is greater than that of non-native salmonids. Once Bonneville cutthroat trout populations have stabilized in the next 5-10 years, it is expected that these populations will provide a popular and unique fishery.

Introduction

When Great Basin National Park was established in 1986, the enabling legislation specifically stated that the Secretary of the Interior "shall permit fishing on lands and waters under his jurisdiction within the park." At that time, it was believed that all fish in park streams were non-native salmonids, despite the east side of the park being located in the Bonneville Basin (Figure 1), the native range of the Bonneville cutthroat trout (*Oncorhynchus clarki utah*) (BCT). National Park Service (NPS) management policies direct that the NPS will maintain natural ecosystems by "preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur (NPS Management Policies 2000)." In order to find a balance between fishing opportunities and preservation of native species in its fisheries program, the park has focused on two main issues: reintroduction of Bonneville cutthroat trout back into its native range and recreational fishing for the visiting public.

BCT Background

BCT have experienced major declines throughout their range and were once thought to be extirpated from Great Basin NP. Endemic to the Bonneville Basin, this subspecies of cutthroat once flourished in Lake Bonneville. At its highest extent, Lake Bonneville included the Snake Valley arm that reached to the streams on the east side of the southern Snake Range, which are now mostly encompassed within the park. The Snake Valley population of BCT became

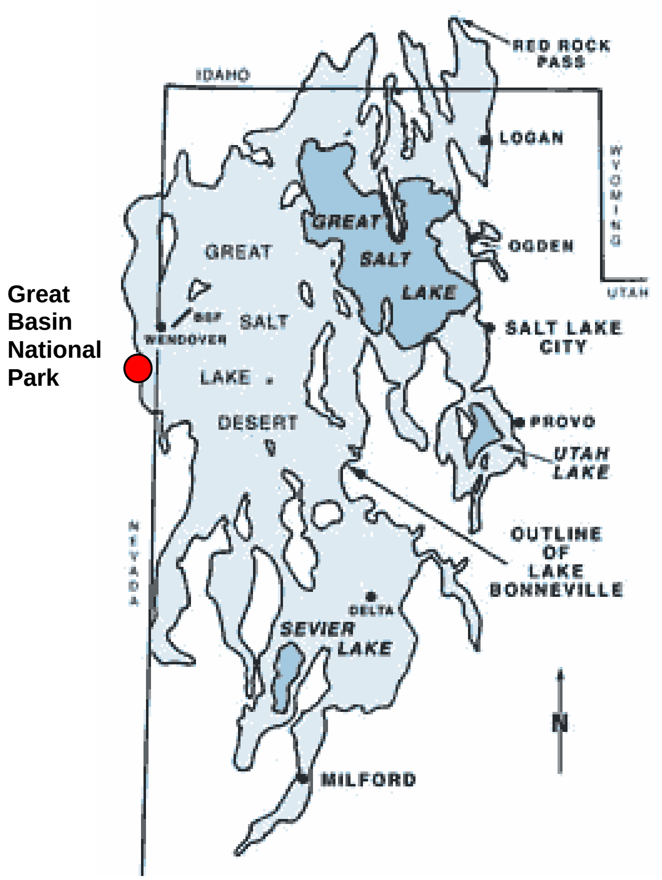

Figure 1. Former extent of Lake Bonneville.

isolated from the rest of the basin beginning about 8,000 years ago, when the lake started shrinking (Behnke 1976). Such reproductive isolation allowed sufficient time for considerable genetic divergence, and scientists suggest this population should be considered a unique race or group (Behnke 1988, 1992; Shiozawa et al. 1993) which is called the Western BCT (USDA Forest Service 1996).

The large-scale extirpation of Western BCT was due largely to habitat alterations following human settlement of the area and the indiscriminate and widespread stocking of non-native salmonids (brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), Lahontan cutthroat trout (*Oncorhyncus clarki henshawi*) and Yellowstone cutthroat trout (*Oncorhyncus clarki bouvieri*)). The presence of non-native fish continues to be a threat to efforts for recovery of BCT. Habitat alterations such as livestock grazing have ceased, with all livestock grazing permits on the east side of the park retired by the Conservation Fund in 2000. Logging that was undertaken when the land was administered by the US Forest Service has since ceased, but its effects are still evident, particularly with the network of logging roads.

In 1998, an interagency team composed of the Humboldt-Toiyabe National Forest (HTNF), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS) and Nevada Department of Wildlife (NDOW) convened at Great Basin NP and developed a proposed action for the reintroduction of BCT to historic range within and adjacent to the park. A BCT Reintroduction Plan and accompanying Environmental Assessment were completed and signed by the Regional Director on November 10, 1999. The primary objective of the plan was to reestablish viable populations of western BCT, the only native salmonid to Great Basin NP.

The park's effort was not isolated, and in 2000, a range-wide Conservation Agreement was finalized and signed by the wildlife agencies of the states of Utah, Wyoming, Idaho, and Nevada, along with the HTNF, BLM, FWS, NPS, and Utah Reclamation Mitigation and Conservation Commission, with support from Trout Unlimited and other organizations. This range-wide agreement coordinated BCT restoration efforts to prevent its listing under the Endangered Species Act.

Habitat

In 2000, there were an estimated 30 miles of historic but vacant Western BCT stream habitat within the park and 56.5 miles, some of which was occupied by Western BCT, on the HTNF. This gives a total estimate of 86.5 miles of historical BCT habitat within the Snake Range in Nevada. Based on the estimate that historically 90 percent of these stream miles contained Western BCT, about 94 percent of the Western BCT populations had been extirpated (USDA Forest Service 1996).

Objectives

The objectives of Great Basin National Park's 1999 Bonneville Cutthroat Trout Reintroduction and Recreational Fisheries Management Plan included: 1) reintroduce viable populations of BCT with enough separate populations so that catastrophic events would not lead to the loss of all populations within the park; 2) over time evaluate and develop the sport fishery potential of this unique species for the enjoyment of current and future generations; 3) increase the knowledge of fishing and accessibility to Baker and Lehman Creeks.

Methods

Recreational Fishing

In order to increase the knowledge of fishing in the park, a number of articles were written and distributed through various media. Volunteers were recruited for population surveys, thinning projects, and trail building to increase access to popular fishing areas. Fisheries resources were included to a greater degree in park planning.

BCT Reintroduction

Reintroducing BCT into park streams required a lengthy and time-intensive process, including 1) baseline surveys, 2) pre-treatment monitoring, 3) treatment, 4) post-treatment effectiveness monitoring, 5) reintroduction of BCT, and 6) post-reintroduction effectiveness monitoring.

Baseline surveys were completed first to determine if the stream was suitable for BCT reintroduction. Physical habitat surveys used the EPA's Rapid Bioassessment of Creeks and Small Rivers protocols (1999), including substrate size, riparian cover, mapping selected reaches, and noting habitat characteristics and condition. Amphibian surveys searched for adults, tadpoles, and egg masses using standard North American Amphibian Monitoring Protocols. Water quality measurements included temperature, dissolved oxygen, conductivity, pH, turbidity and flow, along with taking a water sample that was analyzed in the park's water quality lab for nitrates, phosphates, alkalinity, hardness, sulfates and silica. Macroinvertebrate surveys followed the EPA's Rapid Bioassessment of Creeks and Small Rivers protocols and included both riffle only-quantitative and multi-habitat-qualitative surveys. All samples were sent to the Utah State University Buglab for analysis. Mollusk surveys were also conducted and sent to the Buglab for identification. Fish surveys found the last fish in each selected stream so that the treatment could be focused and have less impact on the rest of the stream ecosystem.

Baseline surveys showed that Mill Creek (Figure 2) contained a pure BCT population, previously identified as a hybrid population, but confirmed by two genetics labs as pure. The known BCT population in Pine and Ridge Creeks, outside of the historic range, were also confirmed to be a pure population.

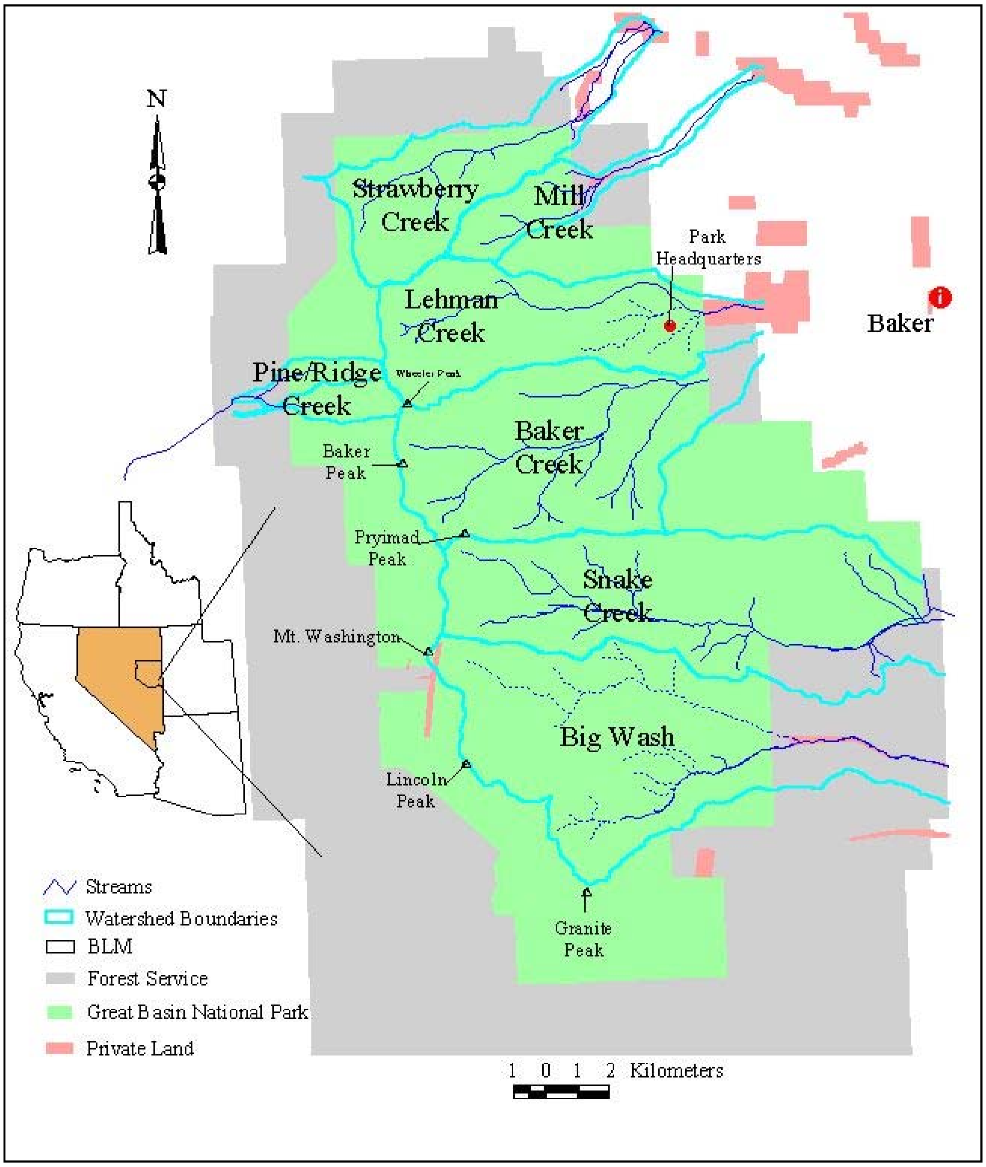

Figure 2. Map of Great Basin National Park streams.

Additional streams were selected for BCT reintroduction: Strawberry, South Fork Big Wash, Upper Snake, and South Fork Baker Creeks. These streams were studied more intensely during the pre-treatment monitoring stage, which repeated water quality, macroinvertebrate, mollusk, and amphibian surveys.

Treatments consisted of electrofishing (South Fork Baker) or using a chemical pesticide, either rotenone (Strawberry Creek) or antimycin (Upper Snake Creek), to kill all the non-native fish in the selected area. Creeks that were chemically treated were divided into sections and had drip-stations applying the chemical at a measured rate. Small seeps and springs along the stream were treated by applicators using backpack sprayers. Each creek had the equivalent of two treatments during the course of a week to ensure that all non-native fish were killed. South Fork Big Wash required no treatment due to a flash flood in 1953 that removed all fish from the reintroduction site.

Post-treatment surveys began one week after the treatment and were repeated at one-month, nine-months, and one-year post treatment. These surveys included water quality, mollusk, and macroinvertebrate analyses. Once the post-treatment surveys indicated that macroinvertebrate population and diversity numbers had reached 75% of pre-treatment levels, BCT were reintroduced into the stream in the fall.

To determine the success of the BCT reintroduction, post-reintroduction surveys were done, including annual population surveys of BCT using standard three-pass depletion methods. Distribution surveys include spot shocking the streams to determine the rate of BCT movement from the reintroduction sites.

Results

Recreational Fishing

Focus on recreational fishing was accomplished by articles in the park newspaper, available to all park visitors; fishing information on the park website (www.nps.gov/GRBA); and the Snake Range Recreational Fishing brochure (Figure 3), a full-color brochure produced in cooperation with NDOW, HNF, and BLM. This brochure is posted at area kiosks and distributed by local agencies and businesses. Additional media coverage has included interviews for PBS stations, radio interviews, and an article in the International National Park Magazine. These efforts have helped the park develop a strong volunteer base, with over 1600 volunteer hours contributed from 2000-2003. Access to recreational fishing areas was increased by Trout Unlimited volunteers who conducted riparian enhancement activities such as thinning along an overgrown section of Baker Creek. In addition, a trail was constructed from Baker Creek campground to Grey Cliffs campground, with fishing areas next to Baker Creek. Recreational fishing has also been included in park planning to a greater degree: the park's new fire plan includes consideration for fishery resources; best

Figure 3. Cover of Snake Range Recreational Fishing brochure

management practices are incorporated for culverts and road grading to minimize sediments affecting spawning areas; and post-fire rehabilitation has been conducted, particularly in the South Fork of Big Wash watershed, to minimize erosion into the stream.

Volunteers have been essential to completing population surveys on recreational fishing streams within the park. The most popular areas for angling are Baker, Lehman, and Snake Creeks, the largest creeks in the park. All three of these streams were stocked on a regular basis from 1924-1986, with at least 400,000 fish stocked during this time period. Stocking ceased with the establishment of the park in 1986, and some anglers complained that the fisheries was declining. The park began completing its own fish surveys in 1999 after the Southern Nevada Chapter of Trout Unlimited purchased two electrofishers. Since then the park has conducted more population surveys than had been done during the 62 years fish had been stocked in the stream.

The population surveys show two trends: the number of fish in these three main creeks is increasing, but the size of brown trout (the most common trophy fish of the area) is decreasing (Table 1). It must be noted that NPS surveys followed the 3 pass, 100 m depletion method, while the NDOW surveys used the 1 pass, 100 ft method. Although these different methods are certainly responsible for some of the difference in number of fish/mile estimated, some of the NPS surveys estimated double the number of fish/mile as previous surveys.

Table 1. Number of fish/mile and lengths of fish in selected reaches for Lehman, Baker, and Snake Creeks.

		Average Fork Lengths (mm)					
Year	**Estimated Fish/mile**	**Brook**	**Brown**	**Rainbow**	**YOY**	**Method**	**Survey by**
LEHMAN CREEK FROM PARK BOUNDARY TO LEHMAN CREEK CG							
2003	2528	137	190	162	65	3 pass, 100 m	NPS
1990	774*	149	230	134		1 pass, 600 ft	NDOW
1984**	1373*					1 pass, 100 ft	NDOW
1952	163					not specified	NV Fish & Game
BAKER CREEK FROM GREY CLIFF NARROWS TO TRAILHEAD							
2003	2527	156	157	165	77	3 pass, 100 m	NPS
1990	1088*	140	163	154		1 pass, 500 ft	NDOW
SNAKE CREEK FROM REARING STATION TO PIEPELINE OUTLET							
2002	1545		136			3 pass, 100 m	NPS
1990	905*		147			1 pass, 680 ft	NDOW
2000	2495	109	138		54	3 pass, 100 m	NPS
1984	1003		204	213		1 pass, 100 ft	NDOW
1960	501***					unknown	NDOW

** Estimates include recorded misses*

***Pop survey done 17 days after a plant of 749 fish; 41% of fish caught were planted based on fin wear characteristics*

****Estimate includes 26 smooth sculpin/mile*

Although most anglers now fish for non-native species, when the reintroduced BCT become established, estimated in approximately 5-10 years, anglers should have an excellent fishing opportunity. Since BCT have evolved in these mountain streams, they have been able to adapt to food and environmental conditions better than non-natives, and can grow larger. The density of BCT in Mill Creek is 66 fish/100m2, which is more than the density of brown, brook, and rainbow trout combined in Lehman Creek (54 fish/100 m^2) or Baker Creek (62 fish/100 m^2) (Figure 4).

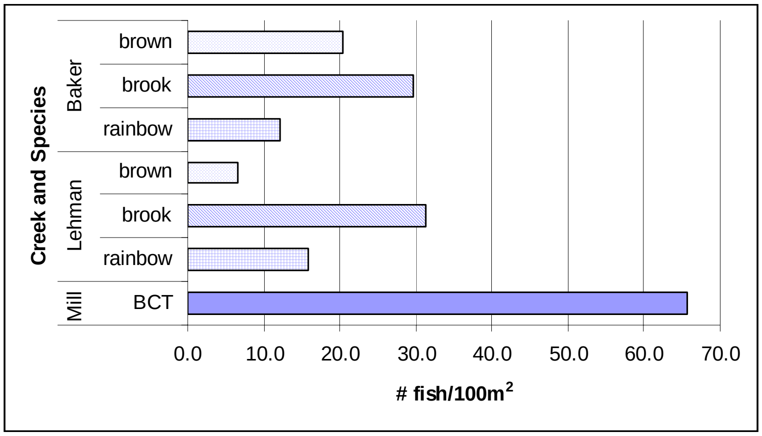

Figure 4. Density of trout species in selected creeks. v

Bonneville cutthroat trout

Currently BCT reside in 17 miles of streams in and near the park, and they have quickly adapted to their new habitats. Spawning success was evident in both Strawberry and South Fork Big Wash creeks the year following reintroduction. Fifty-six BCT were moved from diminutive Mill Creek (Figure 5) to South Fork Big Wash, and in just two years had grown 60% longer (Figure 6), with the largest bigger than any BCT found in Mill Creek.

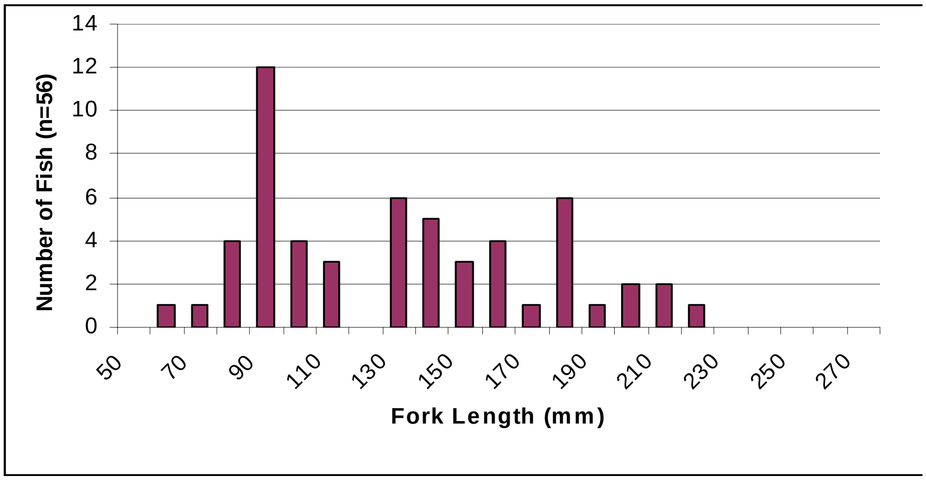

Figure 5. Length of BCT moved from Mill Creek to South Fork Big Wash in July 2000.

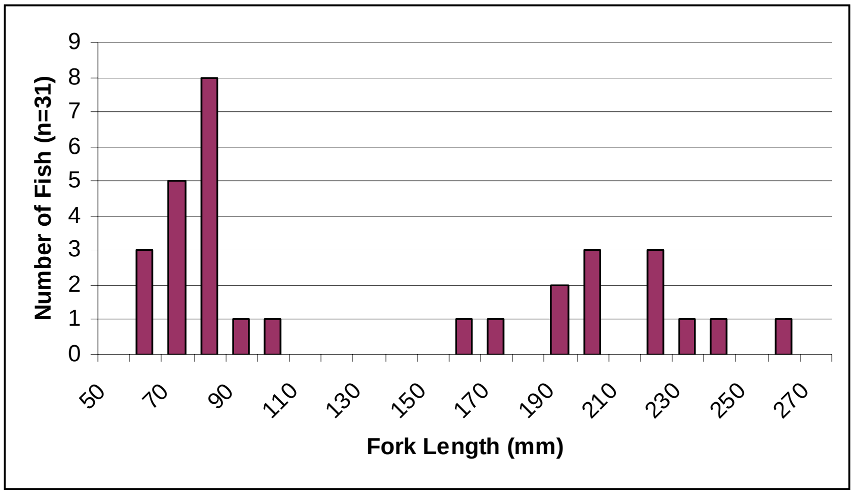

Figure 6. Length of BCT in South Fork Big Wash in August 2002.

The timeline for this project was relatively short, given the nature of the funding. Therefore, a huge emphasis was placed on macroinvertebrates as indicators of stream health. Macroinvertebrates were collected in the spring and fall for two years prior to treatment in Strawberry Creek and three years prior to treatment in Snake Creek. They were also collected one-week prior to treatment, and following treatment at one week, one month, nine months, and one year. The recovery rate of macroinvertebrates to rotenone and antimycin was one of the goals of the project in order to provide information to fisheries managers considering indicate that following the rotenone treatment on Strawberry Creek, overall macroinvertebrate numbers declined 85%, while EPT numbers declined 99%. The antimycin treatment on Snake Creek had a smaller effect on macroinvertebrates, causing their numbers to decline 61% overall, and 54% for EPT taxa. (Figure 7). Macroinvertebrate diversity was severely impacted by rotenone, with 95% decline in taxa one month after treatment in Strawberry Creek, compared to 29% decline in Snake Creek.

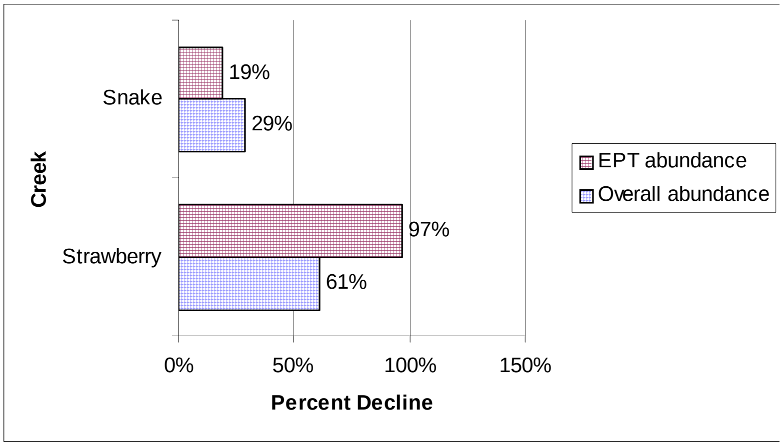

Figure 7. Decline of macroinvertebrate abundance one month following the antimycin treatment on Snake Creek and the rotenone treatment on Strawberry Creek.

Discussion

The park believes that the BCT reintroduction project has not only been one of the most successful park projects but an outstanding example of NPS management. The task of restoring an extirpated species was found to be complex and required persistence and dedication to achieve that goal. BCT have not only been restored to previous habitat and currently occupy 17 miles of creek in and near the park, but due to these efforts, this project precluded the need for listing the BCT as threatened under the Endangered Species Act. This project is an example of proactive management in fulfilling the NPS mission. Park staff have made great efforts to share the results of the BCT project with the public with a mostly positive response. Nonetheless, a project this large is bound to have difficulties. Overcoming these difficulties and learning lessons from them has helped with other projects and may help other parks and agencies that are attempting to do similar fisheries restoration projects.

Lessons Learned

One of the biggest lessons that the park learned is that fish are highly political. NDOW created numerous hurdles for the park by questioning projects and blocking progress, especially for the Snake Creek treatment, Johnson Lake treatment, and moving BCT into Strawberry, South Fork of Big Wash and Snake Creeks. By using the best available science, the park addressed all these issues and worked cooperatively. These issues mainly stemmed by NDOW's reluctance to recognize that the Great Basin NP enabling legislation placed the management of both the habitat and the fish and wildlife within its boundaries under the direction of the Secretary of Interior.

Adaptive management has played an extremely important role throughout the project. One example is when BCT were found in Mill Creek, it suddenly became unnecessary to complete a treatment on that creek, and Mill Creek became a donor population. This saved the last relict population within the historic range of BCT in Great Basin NP. This discovery helped to speed up reintroduction efforts given the inability of NDOW to meet its commitment to supply fish for the project. When the park learned from a local that Johnson Lake spilled over to Snake Creek during runoff in high snow years, the park listened and determined that the lake would have to be treated to protect the BCT population below.

Streamside incubators were used to help hasten the reintroduction process. Trout Unlimited provided the first incubators and the expertise of how to use them. Park staff monitored Mill Creek intensely to determine when BCT were spawning, since that information had not been obtained previously. Eggs and milt were gathered from spawning BCT, mixed together to fertilize the eggs, then transported on ice to the incubators in Strawberry Creek. Although the eggs started out well, low water flows mixed with high sedimentation caused fungus to grow out of control on the eggs, and none survived. Larger wild populations, higher water flows, less turbidity, and a more easily accessible site would all help to make the incubators work better. Although the use of streamside incubators was not successful, the information gained about the spawning BCT was of great value.

From the beginning of the project, the park knew that it could not follow the timetable used by NDOW for their fisheries restoration projects, which is generally waiting 5-10 years after a stream has been treated to reintroduce BCT.

Therefore resource managers decided to limit the treatment reach through intensive pre-treatment surveys that determine fish distribution and to monitor the macroinvertebrate population intensely to find out just how soon BCT could be reintroduced into the stream and have a sufficient food base. This information, coupled with the comparison of how streams respond to both rotenone and antimycin treatments, is of great interest to fisheries personnel for better managing their streams. Since the park has shared the preliminary results of how fast macroinvertebrates return, NDOW has changed their timetable, and reintroduced BCT into Big Wash Creek only two years after treatment.

The Future

The park looks forward to watching park BCT populations develop into self-sustaining populations. The BCT will then provide a popular and unique fishing experience. The park will periodically reassess its fisheries program to determine if it is achieving the goals of the fishery management plan. Finally, by carrying out this project, the park has helped to achieve the NPS mission to preserve the native fauna for future generations.

Acknowledgements

We thank the many field technicians and volunteers who assisted with the Bonneville cutthroat trout reintroduction project. This project was supported by the National Park Service and Trout Unlimited.

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Recovery and Management of Native and Non-Native Fish Populations in the Bear Butte Creek Watershed in the Black Hills of South Dakota Following Historic and Recent Mining Activity

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ABSTRACT—When Lt. R.I. Dodge and the U.S. Army conducted a scientific exploration of the Black Hills of Dakota Territory in 1876; the only fish reported were suckers and dace. Since the introduction of trout in the 1880's, wild brook (*Salvelinus fontinalis*), brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) populations have become established in the streams of the Black Hills. Today, trout anglers fish about 500,000 days a year in the Black Hills. Since 1992, South Dakota Department of Game, Fish and Parks has monitored the longnose dace (*Rhinichthys cataractae*), mountain sucker (*Catostomus platyrhynchus*), and brook trout populations within the Bear Butte Creek watershed. Mining activity within the Bear Butte Creek watershed began with the gold rush of 1876 and concluded in 1998 when the Gilt Edge Mine ceased operation and was designated as a Superfund Site by the EPA. There has been a steady recovery of the native and non-native fish populations in Bear Butte downstream from the Gilt Edge Mine since 1998. Currently the State of South Dakota and the EPA are developing remedial objectives for the Gilt-Edge Mine that includes objectives to insure the future existence of native and non-native species within this watershed. Questions that still need to be answered relate to the suitability of the Bear Butte Creek watershed as a refuge for Black Hills native fish species and the acceptability of native fish species management in this watershed by recreational anglers.

Introduction

In 1995, South Dakota Department of Game, Fish and Parks (SDGFP) mailed 3,448 questionnaires to anglers who had been interviewed by creel clerks the previous year as part of a year-long Black Hills angler use and preference study (Erickson and Galinat, unpublished report). A total of 2,209 (68%) anglers returned a completed questionnaire. After being informed that trout were not native to the Black Hills, anglers were asked if SDGFP should manage for native fish in the Black Hills. Although a small percentage of the respondents failed to answer the question (6%), 29% of the anglers responded "yes", 21% responded "no", and a high percentage (44%) had no opinion.

Currently, none of the streams in the Black Hills of South Dakota are managed explicitly for native fish, nor have quantifiable objectives been developed for the native fish populations. The purpose of this study was to determine the status of the fish populations in the Bear Butte Creek watershed and evaluate the potential for SDGFP to manage this watershed for native and non-native fish.

Watershed Description

Bear Butte Creek is located in the Northern Black Hills of Western South Dakota. It is an extension of the Middle Rockies Ecoregion and shares with it a montane climate, hydrography, and land use pattern (Bryce et al. 1998). Ranching, woodland grazing, logging, recreation, and mining are common activities within the watershed. Bear Butte Creek originates in the granitic core of the Black Hills at elevation of approximately 6,000 feet. It flows over metamorphized areas before, losing all its flow to sink holes in the limestone that surround the Black Hills.

Mining played a significant role within the Bear Butte Creek watershed. The entire Black Hills area was once called the richest 100 square miles on earth for its geologic resources. Small mining claims intersect nearly the entire stream coarse before it enters the historic mining town of Galena and the Galena Mining District. Approximately 8 km below the headwaters, Bear Butte Creek is joined by Strawberry Creek. As early as 1940, extensive mine drainage was documented in Bear Butte Creek below Strawberry Creek that drained the Gilt Edge Mining District. Common mining practices at the time often led to mine wastes entering nearby waterways. This was the case in the lower Bear Butte watershed where stream disposal of tailings had widespread public approval in an effort to plug the limestone sinkholes and increase the availability of water to downstream users. The mine drainage from the Gilt Edge Mine contained effluent from an oil flotation mill, runoff from cyanide tailings dumps and water pumped from the underground mine. Discharge of mine wastes continued until the mill closed in 1941. Subsequently, Bear Butte Creek from the headwaters to the Lawrence County line was severely impaired by heavy metals and elevated total suspended solids from tailings left along Strawberry Creek after mining (SDDENR 2004).

In 1986 Brohm Mining Corporation received a surface mining permit to heap leach ore on the Gilt Edge properties. The mine permit contained provisions to remove or stabilize the remaining tailing in Strawberry Creek. Brohm Mining Corporation completed the cleanup of the historic, acid generating Gilt Edge Tailings along Strawberry Creek in 1995. This resulted in a significant improvement to the watershed (SDDENR 1995). Surface water quality assessments for water years 1996-2001 and current assessments along the entire monitored length of Bear Butte Creek have fully supported all assigned beneficial uses (SDDENR 2004). However, periodic releases of solutions containing cyanide, low pH water or metals have exceeded SD water quality standards in both Strawberry and Bear Butte Creeks. The State took over remedial activities in 1998 when Brohm Mining Corporation filed bankruptcy and mining at the Gilt Edge properties ceased. The mine site has been added to the National Priorities List for releases of cadmium, cobalt, copper, manganese, lead and zinc that have been documented in Strawberry Creek. The EPA is still considering final alternatives for the site, and currently only a few remaining workers operate the water treatment system (USEPA 2004).

Methods

Since 1992, the SDGFP has monitored fish populations by conducting multi-pass electrofishing surveys on all of the perennial streams in the Black Hills. This information is stored in a centralized database and is integrated with a GIS coverage of 360 electrofishing sites that have been established in the Black Hills. Block nets are placed at the top and bottom of the 100m long electrofishing sites to prevent fish from moving into or out of the site. Standard operating procedures require a minimum of three electrofishing passes be completed with backpack electrofishers. Fish from each pass are kept in separate holding cages. Total length (mm) and weight (g) are recorded from all trout and for a minimum of 100 individuals for all other species. Wetted stream width is measured to the nearest 0.1 meters at 11 equally spaced transects and the mean width and stream length were used to calculate fish productivity estimates on a per area basis.

Six electrofishing sites were established in the early 1990's to monitor the fish populations downstream from the Gilt Edge Mine (Figure 1). The electrofishing site immediately upstream of the confluence with Strawberry Creek was established to represent reference conditions since there is no runoff to Bear Butte from the Gilt Edge Mine upstream of Strawberry Creek. The electrofishing site immediately downstream of Strawberry Creek was selected since it is the most upstream section of Bear Butte Creek that is exposed to water discharged from the Gilt Edge Mine. Electrofishing sites were also established immediately above and below the confluence with Ruby gulch which has been used as the repository for spent ore and waste rock. Two additional electrofishing sites were established approximately 2 km downstream of the Gilt Edge Mine at the historic Double Rainbow Mine. These sites bracket an abandoned mine that produces "yellow boy" precipitate from relic tailings. Bear Butte Creek becomes an intermittent stream approximately 1.5 km downstream of the Double Rainbow Mine when it crosses a limestone outcrop.

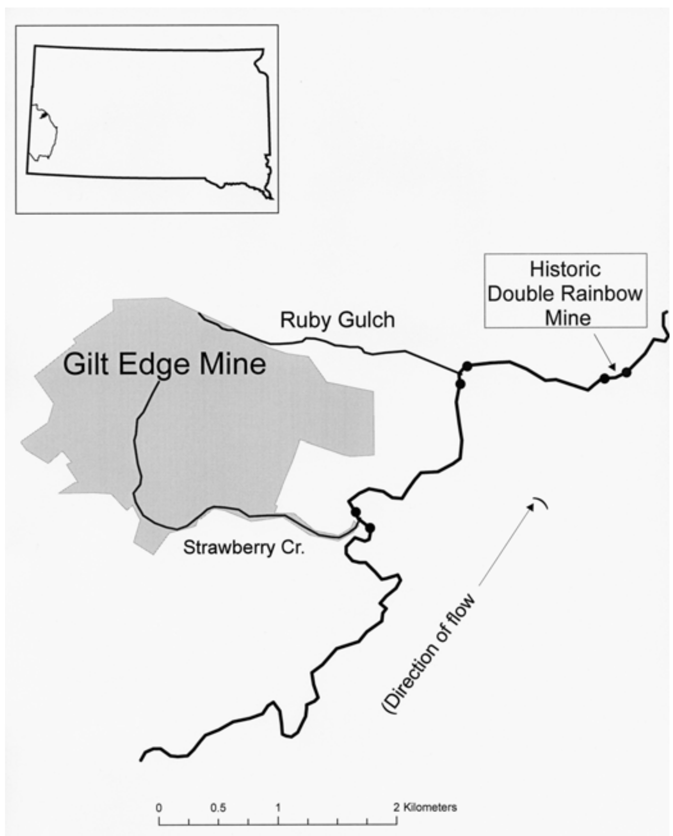

Figure 1. Location of six electrofishing sites on Bear Butte Creek that were selected to monitor the fish populations downstream of the Gilt Edge Mine EPA Superfund site in the Black Hills of South Dakota.

The minimum number of electrofishing passes was increased to four in 1998, when the Gilt Edge Mine was officially designated as "Superfund" Site by the EPA. The number of passes was increased so as to decrease the size of the error term associated with the population estimates. Population density estimates were calculated using Burnham's maximum-likelihood estimate for removal depletion surveys (Platts et al. 1983).

Results

Three hundred sixty fish population monitoring sites have been established in the Black Hills. A total of 858 multi-pass electrofishing surveys have been conducted by SDGFP and several consulting firms since 1992. The majority of the perennial streams in the Black Hill capable of supporting fish are found in the northern and eastern portions of the Black Hills (Figure 2). Mountain suckers were collected at 75 sites and longnose dace were collected at 147 sites. Both of these species have been collected from the majority of the electrofishing sites within the Bear Butte Creek watershed (Figure 2). Brook trout have been collected at 147 sites and are more widespread in the Black Hills than the brown trout. Brown trout have not been documented within the portion of the Bear Butte Creek watershed that is within the Black Hills Trout Management Area.

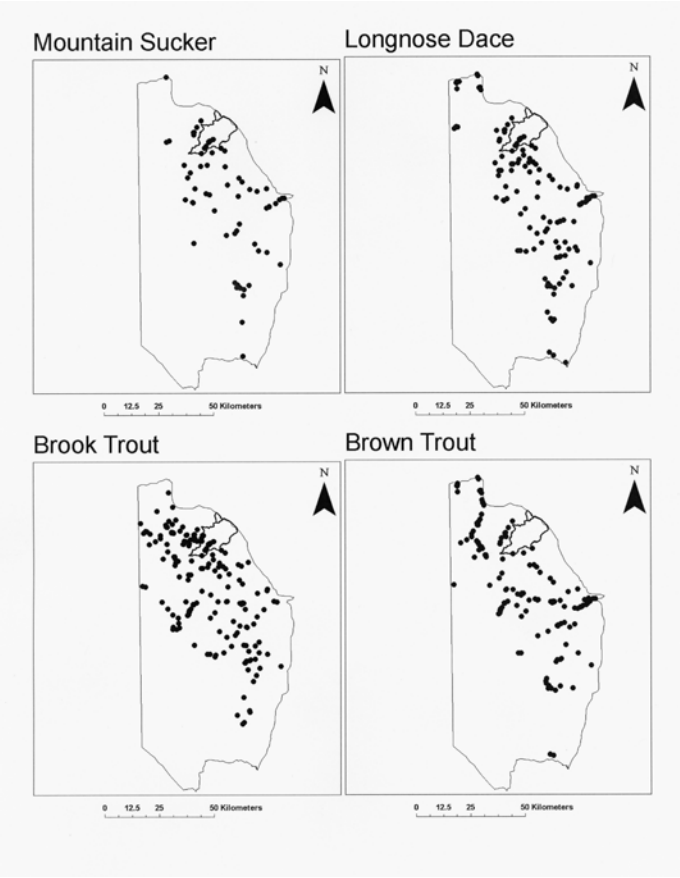

Figure 2. Distribution of mountain suckers, longnose dace, brook trout, and brown trout within the Black Hills Trout Management Area of South Dakota. Fish population surveys were conducted by SDGFP (1992-2003). The boundary for the Bear Butte Creek watershed is identified for each map.

The population density of longnose dace, brook trout and mountain sucker were lower in 1998 than in 1997 (Figure 3). Longnose dace were not sampled from Bear Butte Creek downstream of the confluence with Strawberry Creek in 1998. However, the estimated density of longnose dace upstream of the confluence with Strawberry Creek exceeded 700 fish per 100 m of stream. Since 1998, the density of longnose dace in Bear Butte Creek downstream from Strawberry Creek has increased. The density of brook trout in Bear Butte Creek downstream from the confluence with Strawberry Creek has increased since 1998. Since 2000, the density of brook trout in Bear Butte Creek downstream from Strawberry Creek has been greater than the density of brook trout upstream from Strawberry Creek. In recent years the density of mountain sucker in Bear Butte Creek downstream from Strawberry Creek has been similar to the density of mountain sucker upstream from the confluence with Strawberry Creek.

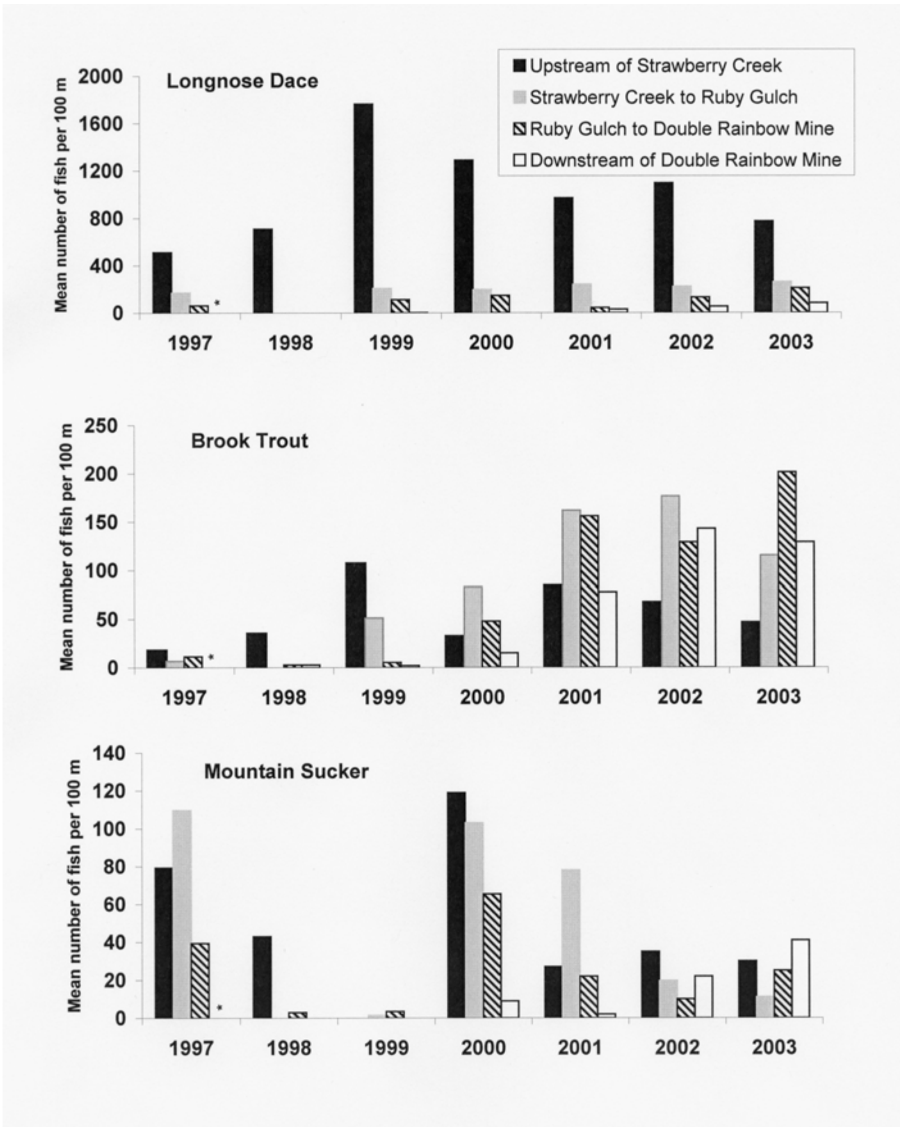

Figure 3. Fish population density estimates in Bear Butte Creek near the Gilt Edge Mine from 1997 to 2003. Asterisk denotes electrofishing surveys were not conducted downstream of the Double Rainbow Mine in 1997.

Discussion

The mountain sucker and the longnose dace are two of only a handful of fish species that are widely accepted as being native to the streams of the Black Hills. Although neither of these species supplies sportfishing opportunities for anglers, SDGFP is responsible for insuring neither are extirpated from South Dakota. Current South Dakota Codified Law (SDCL 34A-8-6) states “The Department of Game, Fish and Parks and the Department of Agriculture shall perform those acts necessary for the conservation, management, protection, restoration, and propagation of endangered, threatened and nongame species of wildlife”. Although neither of these species is listed by the State of South Dakota as threatened or endangered, extinctions or declines in native fishes are not unheard of in North America. Miller et al. (1989) reported the loss of 3 genera, 27 species and 13 subspecies of fish from North America in the proceeding 100 years. Patton et al. (1998) documented a decline in 12 of 31 native species of fish in the Missouri River drainage of Wyoming from the 1960s to the 1990s.

Brown trout are more piscivorous than brook trout or rainbow trout. The lack of brown trout within the Bear Butte Creek watershed may explain the high density mountain sucker and longnose dace in this drainage. SDGFP does not stock brown trout in Bear Butte Creek or any of its tributaries within the Black Hills Trout Management Area. However, an unauthorized stocking of brown trout in this drainage could negatively impact the brook trout, longnose dace and mountain sucker populations.

The Bear Butte Creek watershed has been identified by SDGFP fisheries staff as the watershed with the largest populations of longnose dace and mountain suckers within the Black Hills Trout Management Area. The SDGFP fisheries staff is currently working with the EPA to develop post-closure objectives for the Gilt Edge Mine Superfund Site that address non-native as well as native fish issues.

Acknowledgements

We wish to thank Michael Erickson (SDDENR) and Greg Simpson (SDGFP) for assisting with the preparation of the site location map and species distribution figures. Michael Cepak (SDDENR) provided access to documents and records about the history of Mining in the Bear Butte Creek watershed. The SDGFP Region I fisheries staff along with Dan Wall (USFWS) and Dale Hoff (USEPA) assisted with the annual electrofishing surveys in Bear Butte Creek.

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A Collaborative, Multi-Faceted Approach to Yellowstone Cutthroat Trout Conservation in the South Fork of the Snake River, Idaho

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ABSTRACT—The South Fork of the Snake River supports a world-renowned fishery and one of the most important Yellowstone cutthroat trout populations in their historical range. Rainbow trout were a negligible component of the trout population until the late-1980's. In the past 15 years angler and electrofishing surveys have shown a steady increase in rainbow trout to where they are now as abundant cutthroat trout in the upper reaches of the river. In cooperation with other agencies and non-governmental organizations, the Idaho Department of Fish and Game is working on three fronts to protect and maintain the health of the cutthroat population. First, weirs and fish collection traps have been constructed on the four main tributaries to allow collection of cutthroat and rainbow trout spawners. Based on phenotypic examination, cutthroat trout are passed upstream, whereas rainbow and hybrid trout are transported to catch-out ponds. Second, IDFG has been working with Idaho State University and the Bureau of Reclamation to identify and implement flow regimes that are beneficial to cutthroat trout and detrimental to rainbow trout. A comprehensive analysis suggests the magnitude and shape of the spring runoff flows may have a significant effect on the ratio of rainbow to cutthroat trout recruits. Finally, we used an aggressive program combining regulation changes and public outreach in 2003 to encourage harvest of rainbow trout. Prior to 2003, anglers released the majority of rainbow trout caught on the South Fork. In 1996 an estimated 900 rainbow and hybrid trout were harvested out of 12,700 landed, for a retention rate of about seven percent. In 2003, an estimated 5,070 rainbow and hybrid trout were harvested out of an estimated 21,00 landed, for a retention rate of about 25%. Though the 2003 harvest probably equates to around only 10-20% exploitation (depending on size classes included in the estimate), it represents a significant step in an effort to get anglers to take an active role in managing the South Fork cutthroat trout population. Through continued education combined with regulations liberalizing harvest we hope to increase rainbow trout exploitation to 50-70%. We hope the approach used on the South Fork can serve as a model to engage anglers, manage hydrologic regimes, and conserve genetic integrity of native sport fish in other systems.

Introduction

The South Fork of the Snake River, or "South Fork" as the approximately 60 mile reach from Palisades Dam downstream to the confluence with the Henry's Fork is referred to, supports a tremendously popular fishery and one of the most productive and important populations of Yellowstone cutthroat trout in their historical range. This native trout population is one of the few remaining healthy fluvial populations in the Upper Snake basin and therefore has particular biological, ecological, and social value.

The South Fork fishery draws a tremendous number of anglers to eastern Idaho, providing a significant infusion of money to the eastern Idaho economy. A recent economic impact study indicates that anglers spent nearly $14.7 million in 2003 on the South Fork (this figure is actual expenditures and doesn't include any sort of economic multiplier). Such expenditures contribute to a significant outfitting industry, as well as two major drift boat companies headquartered in nearby Idaho Falls.

Much of the appeal of this highly acclaimed fishery lies in the abundance of Yellowstone cutthroat trout. The South Fork is known largely for high catch rates with dry flies, and outfitters advertise that 50 fish/boat in a single day is not uncommon. It is also generally accepted that the high catch rates are a function of cutthroat trout, which tend to be more vulnerable to dry fly fishing than many other trout species.

Several factors threaten the long-term survival of Yellowstone cutthroat trout on a range-wide basis. These include habitat degradation, dewatering, drought, and non-native species. In the South Fork hybridization with non-native rainbow trout and the associated loss of genetic purity is generally recognized as the most imminent threat to cutthroat trout. Rainbow trout, which are not native to the Snake River basin above Shoshone Falls, were stocked throughout the upper Snake drainage for decades before the implications of genetic introgression were recognized. Although rainbow trout stocking in the main-stem and tributaries was discontinued in 1981, a self-sustaining population was established and is, in fact, expanding. In annual electrofishing surveys of the Conant Reach, rainbow trout have increased in abundance from about 1% of the total catch in 1982 to 33% of the catch in 2003 (Figure 1).

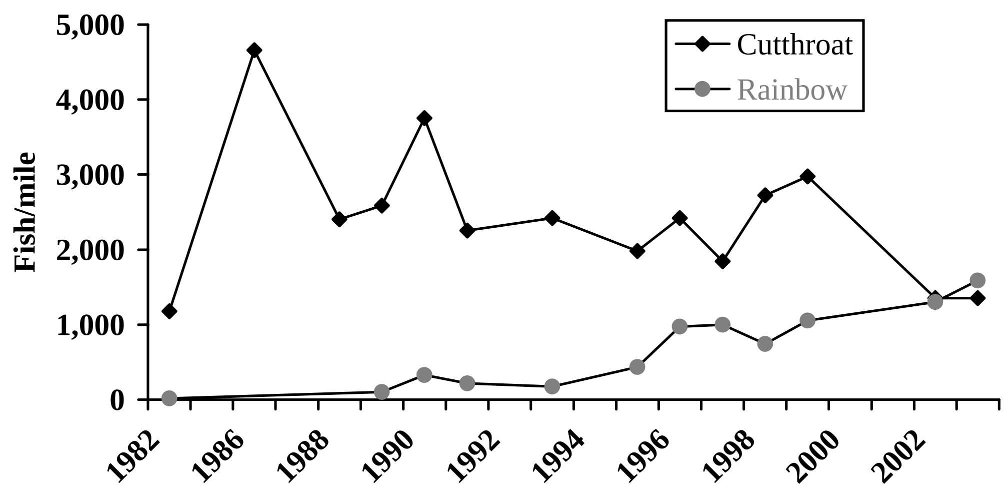

Figure 1. Densities of Yellowstone cutthroat trout and rainbow trout from 1982 through 2003 based on mark-recapture population estimates at near Conant Valley on the South Fork Snake River, Idaho.

Three-prong Approach

The observed rainbow trout expansion in the mid-1990's lead IDFG to begin evaluating available alternatives to insure the long-term survival of Yellowstone cutthroat trout and the associated fishery. A three-prong approach has evolved in the interim period that addresses the need to control the rainbow trout population in the mainstem South Fork and prevent their invasion into tributaries. This approach, which has been developed and implemented largely through a collaborative process, consists of 1) controlling rainbow trout invasion into the major tributaries through the use of fish weirs and traps, 2) implementing flow regimes beneficial to Yellowstone cutthroat trout, and 3) involving anglers in the conservation effort by allowing and encouraging the harvest of rainbow and hybrid trout.

Weirs

A research project was conducted in 1996-1997 to describe where and when rainbow, hybrid, and cutthroat trout spawn. Using radio telemetry, researchers learned rainbow and hybrid trout primarily use main-stem side channel habitat for spawning while cutthroat trout use both main-stem side channel and tributary habitat (Henderson 1999; Henderson et al. 2000).

The research underscored the importance of tributaries in maintaining a genetically pure cutthroat population in the South Fork. As a result, an intensive tributary management program was implemented to preserve the genetic integrity of cutthroat trout spawning in Burns, Pine, Rainey and Palisades creeks. From 1998-2001, in cooperation with the U.S.D.A. Forest Service, the BOR, the Jackson One-Fly Foundation, National Fish and Wildlife Foundation, and Trout Unlimited, IDFG constructed permanent tributary weir and trapping facilities on the four major tributaries with the intent of trapping all upstream migrating trout. Because genetic research has demonstrated near 100% accuracy in field identification of cutthroat with less than 0.5% rainbow trout introgression, IDFG personnel are able to use phenotype to efficiently and accurately sort fish at the traps. Rainbow and hybrid trout are moved to other regional waters where they pose no risk to native species, and cutthroat are allowed to pass upstream to spawn. Because of the extent of mainstem spawning rainbow trout, the intent of the weir program is not to decrease rainbow trout abundance in the mainstem, but rather to prevent invasion of rainbow trout into the tributaries and protect these valuable core areas as genetic refuges for Yellowstone cutthroat trout.

We began the trapping program in March, 2001. Since then, we have successfully trapped and removed over 750 rainbow and hybrid trout spawners and passed over 11,000 Yellowstone cutthroat spawners. Initially, a resistance board floating weir design was used, which is designed to pass debris, thereby minimizing maintenance and increasing effectiveness (Figure 2). Though this design has generally worked during periods of lower flows, it has not consistently been able to withstand the high and variable flows associated with runoff. IDFG is currently working with our agency and non-governmental partners to develop a more effective and efficient weir design. We are optimistic that through modifications of the floating weir design or development of alternative weir structures, we will soon be able to efficiently and effectively trap the vast majority of upstream migrants.

Figure 2. Floating resistance board weir in Pine Creek, Idaho used to divert upstream migrating trout into a collections box (edge of picture in foreground) for phenotypic sorting.

Flows

Palisades Dam was completed by the Bureau of Reclamation (BOR) in 1956, primarily for the purposes of flood control and irrigation water storage. The major impact of the dam, aside from inundation of 19 miles of fluvial habitat and complete blockage of fish migration, was alteration of the hydrograph. Typical of many western river irrigation projects, Palisades Reservoir is operated to store water throughout the winter and spring for delivery in the summer and early fall. The resulting hydrograph is generally one with a minimized peak during the natural runoff period, much higher late summer and early fall flows, and lower winter flows (Figure 3).

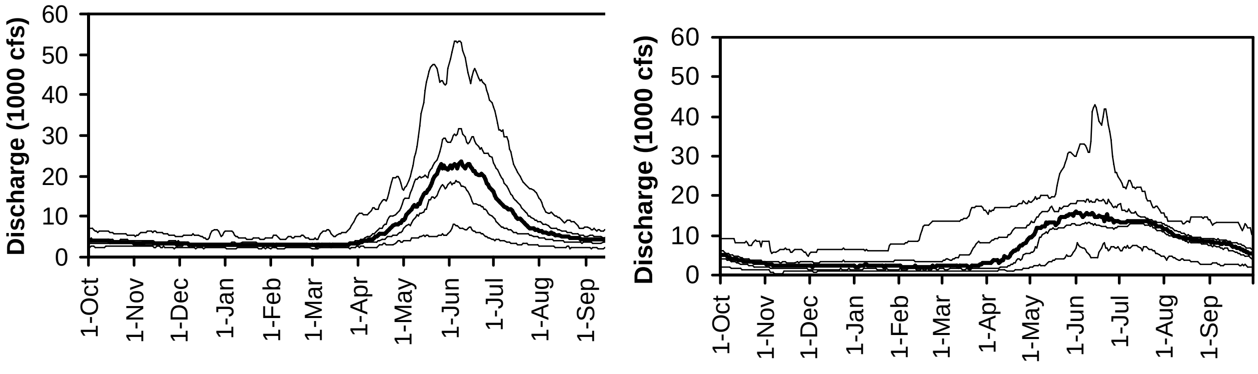

Figure 3. Discharge of the South Fork Snake River, Idaho at the Heise gauging station prior to Palisades Dam (unregulated flow; left), characterized by a pronounced increase in flows in late spring, followed by a return to low flows by late summer, and after the construction of Palisades Dam, charcterized by a moderated and prolonged period of high discharge (right). Bold center line depicts median flow, with the additional lines depicting minimum, 25th percentile, 75th percentile and maximum discharge.

For many years, the focus of fishery conservation efforts was on winter flows. Low winter flows, particularly during dry years, caused significant de-watering of secondary channels of the South Fork, which was believed to cause major losses of juvenile salmonids during winter. The quality and quantity of available winter habitat has been identified as a major factor limiting salmonids abundance in some streams (Mason 1976; Hall and Knight 1981; Tschaplinski and Hartman 1983; Mitro 1999). The expectation was that low winter flows were likely limiting recruitment in the South Fork as well. A multi-agency study of flow-habitat relationships was completed in 1991 that recommended a minimum winter flow release of 1,500 cfs at Palisades Dam (Schrader and Griswold 1994). This target minimum flow was met in the winter of 1995-96 and 1999-2000, but beginning in the winter of 2000-01 flows have not exceed 1,080 cfs because of poor snow pack and low precipitation.

Despite the flow-habitat relationships developed by Schrader and Griswold (1994) there was no conclusive evidence that low winter flows caused poor cutthroat survival. Recognizing drought related constraints on water managers and the uncertainties surrounding the affects of flow regimes, a cooperative project with Idaho State University (ISU) was conducted in 2003 to better define the relationships between flows and fish populations (Moller and Van Kirk 2003). A suite of independent variables that described flow regimes was used in the analyses, including measures of hydrologic alteration (the difference between natural flow and regulated flow), minimum flows, maximum flows, and the ratio of springtime maximum flows to the previous winter minimum flows. The dependent variables were measures of juvenile trout recruitment—specifically age-1 abundance of cutthroat, rainbow, and brown trout as determined by annual electrofishing population estimates in September-October.

A surprising finding was that winter flows were not related to Yellowstone cutthroat trout recruitment, although they were strongly related to rainbow trout recruitment. Ironically, the years where minimum flow exceeded 1500 cfs yielded the strongest cohorts of rainbow trout. Rainbow trout also benefited from years when springtime flows were moderated by flood control. In about one third of the years, water is released from Palisades Dam beginning in late February, resulting in high, but relatively constant flows in the South Fork through June. The higher late winter flows, combined with storage of runoff in late spring, followed by high flows related to irrigation water delivery through mid-fall results in a highly altered flow regime with characteristics more similar to a spring-fed river than a snow-melt driven system.

Not surprising was the finding that years with a more natural flow regime benefited cutthroat trout. Because an unregulated snowmelt driven system is characterized by extreme flows, the ratio of minimum winter flows to the following springtime maximum (max:min ratio) serves as an index of a more natural hydrograph. This ratio was very strongly and positively related to cutthroat trout recruitment, but negatively related to rainbow trout recruitment. The ratio of juvenile cutthroat to rainbow trout was about 8:1 in years with the highest max min ratios, compared to 1:1 in years with the lowest max min ratios.

Based on these relationships, Moller and Van Kirk (2003) recommended that water managers store additional water throughout the winter (i.e., resulting in lower winter flows) for release in the spring to coincide with natural runoff. Fortunately, this scenario, designed to benefit cutthroat trout, is also beneficial to water users, who prefer to store water in the upriver reservoirs throughout the winter, and are amenable to a spring release as long as the water can be caught in a lower reservoir.

This recommendation was implemented in the spring of 2004. Because of the low snow pack, the regulated flow very closely mimicked what flow would have been in the absence of Palisades Dam. Discharge in the South Fork peaked on May 23 at 18,960 cfs (at the Irwin gage), and the max:min ratio was 20.5:1, greatly exceeding the threshold of 10:1 believed to favor Yellowstone cutthroat trout.

Although the mechanism behind the relative success of cutthroat and rainbow recruitment is largely speculative, disruption of gravel and shifting bedload may be a significant factor. Because rainbow trout tend to spawn prior to peak flows, whereas cutthroat trout spawning generally coincides with the descending limb of the hydrograph (Henderson et al. 2000) it seems likely that the redd disturbance may hinder rainbow trout egg survival. Alternatively, a steeply ascending hydrograph may trigger cutthroat trout to initiate a spawning migration or spawn in more favorable habitats. Regardless, we are optimistic that the 2004 flow regime will result in a higher cutthroat to rainbow trout ratio than has been seen in recent years. The effectiveness of the experimental flows will ultimately be gauged by age-1 trout recruitment in the 2005 electrofishing surveys.

Angler Harvest

Like many wild trout fisheries, the South Fork evolved in the 1980's from a largely harvest-oriented fishery to a predominately catch-and-release fishery. A creel survey in 1982 (in the upper river from May through September) indicated that anglers caught almost 48,000 game fish, of which almost 28,000 or 59% were harvested (Moore and Schill 1984). By 1996, the catch had increased to nearly 189,000 fish, but harvest was only 4,568 fish, or 2% (Schrader et al. 2003). The same survey indicated around 900 rainbow and hybrid trout were harvested out of 12,700 landed, for a retention rate of about seven percent. Although regulations had undergone various changes during this period, the harvest was largely limited by self-regulation of anglers. Clearly, with the amount of angling pressure and number of fish handled, anglers have the ability to impact the trout population.

With this in mind, IDFG has worked with Trout Unlimited (TU) and leaders in the local angling and guiding community to develop an aggressive rainbow trout harvest campaign. This has increased the level of awareness and instilled a sense of ownership in the fishery. Initially, we worked with writers and reporters on newspaper articles, editorials, and television news stories. We then developed a brochure describing the cutthroat/rainbow situation that was distributed through sporting goods stores, angling club functions, and fly fishing expos. In addition to the brochures, signs and posters were erected at informational kiosks at the major boat ramps. A key component of the signs were identification criteria to help anglers accurately distinguish rainbow and hybrid trout from Yellowstone cutthroat trout. Most recently, we developed a lapel (or fishing vest) pin awarded to anglers on the river that had harvested a rainbow trout.

As part of the angler education campaign, but also to assess the current fishery, we conducted a creel survey on the South Fork from January through December 2003. In addition to collecting effort, catch, and harvest information, fishery technicians used the creel checks as an opportunity to discuss cutthroat trout management and to stress the importance of rainbow trout harvest.

Fishing rules during the 2003 creel survey allowed anglers to keep six trout (rainbow and hybrid trout could be any size), only two of which could be cutthroat or brown trout (with a 16 inch minimum size). Because IDFG fishing rules are set on a two-year cycle and were up for changes in 2004, we collected public input throughout the creel survey and in a series of public meetings to discuss potential regulation changes to benefit cutthroat trout.

Results of the 2003 creel survey reflected the population trends apparent in the electrofishing surveys. The percentage of cutthroat trout in the catch declined from 71% in 1996 to 48% in 2003, while rainbow trout increased from 7% of the catch to 20% (in the upper river from May through September; Figure 4). Many cutthroat trout advocates have suggested that catch rates may decline as rainbow trout become more dominant, simply because of the greater vulnerability of cutthroat trout. Evidently supporting this hypothesis, catch rates dropped from 1.12 fish/hr in 1996 to 0.64 fish/hr in 2003. We were encouraged that anglers released nearly all cutthroat trout, with less than 300 cutthroat trout kept out of around 55,500 landed. We were also encouraged that many anglers showed a willingness to harvest rainbow trout. We estimated 5,070 rainbow and hybrid trout were harvested. Though the retention rate was much improved over 1996, participation was far from complete, with around 21,000 rainbow and hybrid trout being released (retention rate of around 25%).

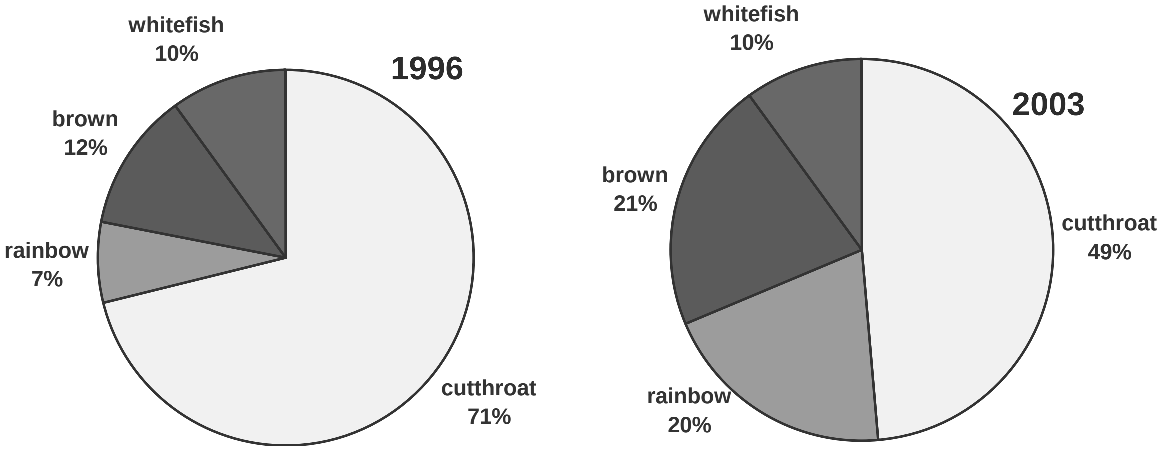

Figure 4. Catch composition based on angler creel surveys conducted in 1996 and 2003 in the upper South Fork Snake River, Idaho from May through September.

We conducted an approximate river-wide population estimate for rainbow and hybrid trout using catch per unit effort (CPUE) at systematically selected sites throughout the river (Schrader and Fredericks, in press). Based on this method, we estimated there were approximately 39,000 rainbow and hybrid trout in excess of eight inches in 2003. This suggests annual exploitation by anglers in that same year was around 12%. Release rates tended to be much higher on smaller fish (8-12 in), however, and when considering only the population of larger rainbow trout (i.e., those over 11 in), exploitation is likely closer to 20%. In either case, we are optimistic that as angler acceptance of rainbow trout harvest mounts along with a native trout conservation ethic we will achieve annual exploitation rates exceeding 50%.

Individual contacts and public meeting comments clearly indicated that most anglers recognized the value of cutthroat trout in the South Fork and strongly supported management actions and rule changes to maintain the cutthroat trout population, even if they had difficulty personally harvesting rainbow trout. In response to the need to encourage rainbow and hybrid trout harvest and protect cutthroat trout, the IDFG commission approved regulations for 2004-05 that allow anglers to keep an unlimited number of rainbow and hybrid trout of any size. In addition, the entire South Fork was opened to year-round fishing, enabling anglers to target spawning rainbow trout in the upper river, where they had previously (and inadvertently) been protected by a general season. Finally, a catch-and-release rule for cutthroat trout was implemented in the mainstem and the major tributaries, and to maximize protection of spawners, a July 1st opening date was applied to the major tributaries.

Although we conducted only occasional and unstructured creel checks in 2004, it seems very evident that the year-round season in combination with allowing unlimited harvest of rainbow and hybrid trout is significantly increasing exploitation. We are optimistic that by 2005, annual exploitation of rainbow and hybrid trout will exceed 40%.

Conclusion

The South Fork represents a unique example of a native fish conservation effort involving water users, anglers, non-governmental organizations, and state and federal agencies. The multi-faceted strategy has been possible because of the extraordinary level of communication amongst stakeholders, a widely held appreciation of the value of the resource, and the recognition of the potential costs of a less productive adversarial atmosphere. We are optimistic the South Fork efforts will ensure a healthy Yellowstone cutthroat trout population into the future. Furthermore, we hope the approach can be used as a model to engage anglers, manage hydrologic regimes, and conserve genetic integrity of native sport fish.

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Managing a Trout Tailwater in the Presence of a Warmwater Endangered Species

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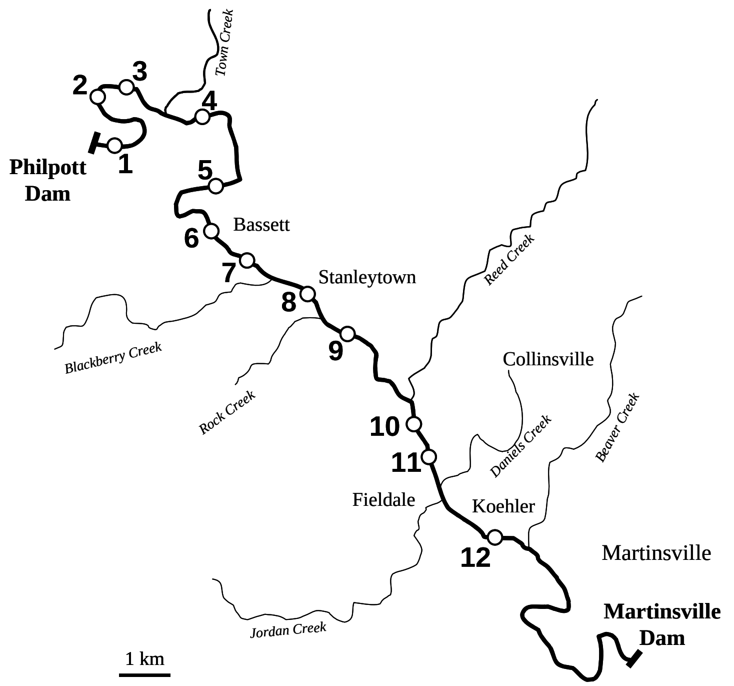
ABSTRACT—Flow and temperature in the Smith River tailwater (southwest Virginia) are influenced by a hydropeaking operation. Hypolimnetic releases support a naturalized brown trout (*Salmo trutta*) fishery and spatially restrict the endemic warmwater ichthyofauna. With trophy trout currently lacking, managers and anglers desire flow and temperature changes to enhance brown trout size and growth. However, management must also protect the endemic warmwater species, including the endangered Roanoke logperch (*Percina rex*). Dynamic flow and water temperature models were used to predict thermal habitat under alternative flow scenarios. Model output and species thermal criteria enabled assessment of potential benefit or detriment to brown trout and warmwater species. Currently the average release temperature (8°C) is below the optimal brown trout growth range (12-19°C). A 12°C outflow scenario predicted the greatest increase of optimal growth temperatures. Warmer temperatures also increase the area of suitable thermal habitat for warmwater species, including the Roanoke logperch. With changes in flow management we found it is possible to improve the trout fishery without detrimental effects to the warmwater community.

Introduction

Hydroelectric impoundments significantly alter the physical and biotic characteristics of the lotic system they control (Cushman 1985; Bain et al. 1988; Allan 1995). The physical effects of hydropeaking often include altered flow and temperature regimes, scouring, and channel and bank erosion (Bain et al. 1988; Allan 1995). Regulation subsequently affects the biota of the aquatic system both physiologically, and in terms of patterns in species assemblage (Bain et al. 1988; Kinsolving and Bain 1993; Allan 1995; Hunter 2003). However, the tailwaters below hydropeaking facilities have proven to provide economically valuable coldwater sport fisheries in geographic locations that could not otherwise support such species (Krause et al. in press).

The thermal characteristics of aquatic ecosystems hold great importance as to the distribution and vitality of ichthyofauna. Temperature is considered a controlling factor in the metabolism of fish, directly affecting physiological rates and efficiencies (Fry 1971; Ojanguren et al. 2001). Hinz et al. (1998) indicate that the thermal regime significantly contributes to growth variations spatially within a system. The process of seeking optimal temperatures in order to regulate metabolic expenditures is an important aspect of life-history in many fish (Hall 1972). Longitudinal differences in stream fish distribution are often a result of the independent responses of species to physiochemical gradients, rather than biotic interactions (Moyle and Li 1979; Matthews and Styron 1981). For this reason, temperature has been viewed as both a resource and a habitat among stream fishes (Magnuson et al. 1979; Ojanguren et al. 2000; Wehrly et al. 2003).

The Smith River is a sixth order tributary of the Dan River located in southwestern Virginia (Figure 1). In 1952, the U.S. Army Corps of Engineers impounded a section of the Smith River with the construction Philpott Dam, resulting in the creation Lake Philpott and the tailwater section of the Smith River. Philpott Dam generates peaking releases year-round, with generation schedules determined by energy demands and water availability. Due to peaking releases, flows fluctuate daily, excluding weekends, between 1.3 cms to 36.6 cms. The temperatures of peaking releases average 8°C, and increase with distance from the dam (Krause 2002). Due to peak flows, temperatures fluctuate hourly, declining up to 10°C in an hour during summer months (Krause 2002). The Smith River tailwater is home to an economically valuable, naturalized population of brown trout (*Salmo trutta*), stocked rainbow trout (*Oncorhynchus mykiss*), as well 33 nongame fish species, including the endangered Roanoke logperch (*Percina rex*). The tailwater, once a trophy brown trout fishery, now produces few trout that exceed 406mm (0.63kg) (Hartwig 1998; Orth et al. 2001; 2002; 2003; Hunter 2003).



Site #	Km below Dam	Section
1	0.5	
2	3.4	Upper
3	4.2	
4	6.2	Trophy
5	8.9	
6	11.9	
7	13.1	
8	14.9	
9	16.5	Lower
10	19.5	
11	20.6	
12	23.7	

Figure 1. Fish sampling sites, which also correspond to temperature model output locations, are numbered upstream to downstream in the Smith River tailwater, southwestern Virginia.

The Roanoke logperch, a large darter, is a noteworthy constituent of the Smith River's nongame fish assemblage due to its rarity. Characteristic of other species in the genus *Percina* , the Roanoke logperch is known to feed primarily on benthic and drifting invertebrates (Jenkins and Burkhead 1993). Rosenberger (2002) concluded that Roanoke logperch are extremely vulnerable to habitat degradation. The Roanoke logperch has a very small total range, and low population densities, occupying several warmwater streams in the Roanoke, Chowan, and Smith River drainages in Virginia (Jenkins and Burkhead 1993). In the Smith River drainage, small populations of Roanoke logperch are found above Philpott Dam, in the lower reaches of the tailwater, as well as in one of the primary tributaries, Town Creek, located approximately 5 km below the dam. Jenkins and Burkhead (1993) state that the Town Creek population is thermally isolated from the population that inhabits the tailwater further from the dam.

We hypothesize that water temperatures in the tailwater, a function of hydropeaking operations, may be limiting trout growth, as well as spatially restricting the distribution of the endangered Roanoke logperch. In this study, we modeled alternative flow scenarios for the Smith River tailwater to determine if there is a temperature regimen that can enhance the growth of brown trout, as well as increase thermal habitat for Roanoke logperch, and similar warmwater species.

Methods

Flow and Temperature Model Development

The influence of alternative flow scenarios released from Philpott dam on water temperature were compared to the baseline flow regime released by the U.S. Army Corps of Engineers (USACE). Hourly flow and temperature was predicted with the dynamic ADYN and RQUAL river modeling system (Hauser and Walters 1995). Flow scenarios were modeled by season (Spring: Mar, Apr, May and Summer: Jun, Jul, Aug) under representative conditions calculated for lateral inflows, lateral inflow temperature, meteorological parameters, and starting water temperature at the upstream modeled end. Spring and summer seasons were chosen for further analysis because of their biological interest in terms of spawning activity and growth patterns. Hourly model output at 12 locations below Philpott dam which correspond to fish sampling sites of a Smith River brown trout study were assessed together as a tailwater, as well as within the upper (0.0-5.3 km), trophy trout managed (5.3-10.0 km), and lower (10.0-24.3 km) reaches (Orth et al. 2003) (Figure 1). Because the representative conditions did not change between the baseline and alternative scenario model runs, comparisons assess changes resulting from an alternative scenario. Alternative scenarios were evaluated for ability to increase occurrence of brown trout optimal growth temperatures (12-19°C), prevent exceedance of 21°C (brown trout maximum), maintain diurnal flux, and reduce maximum hourly temperature declines (MHTD). Detailed methods for model parameter data collection, input file development, calibration, predictive ability, and validation can be found in Krause (2002).

The baseline flow regime was determined using 13 years (1991-2003) of discharge data (USGS 2004). Histograms were used to determine occurrence frequency of typical conditions for baseflow discharge; drawdown discharge prior to peaking flow; and time-of-day of peaking flow. The typical magnitude and duration of peakflows were determined as the average of what occurred. The combination of these variables enabled the development of a representative baseline flow regime released by the USACE each season.

Lateral inflows were calculated for three sections of the tailwater and the Town Creek tributary (Krause 2002). The difference in flow between multiple gages estimated lateral inflows. Seven years of hourly data for cloudiness, dry bulb temperature, dew point, barometric pressure, and wind speed were obtained from the National Climatic Data Center (NCDC 2004) and solar radiation data from the Cooperative Networks for Renewable Resource Measurements (CONFRRM 2004). Representative meteorological parameters were generated as an average across years (1997-2003) within a season (spring and summer) for each of the 24 hours in a day. Water temperature was recorded by data loggers (Krause 2002). The upstream-most logger provided temperatures to initiate the RQUAL model and loggers in tributaries provided lateral inflow temperature data. Mean annual air temperature was also used for lateral inflow temperature depending on season (Krause 2002). Additional temperature loggers were used for model calibration and validation. The average of hourly temperature logger data across years (1999-2003) within a season for each of the 24 hours in a day provided representative conditions.

Three alternative flow scenarios were developed based on two potential modifications to Philpott dam; a depth variable intake allowing selective water temperature release or replacement of the 1950's era turbines with modern turbines. The *12°C outflow scenario* assumes 12°C water within the reservoir is released using the baseline flow regime to achieve temperatures within the reported brown trout optimal growth range (12-19°C) (Table 1) (Raleigh et al. 1986; Smith 1994; Ojanguren 2001). The *new turbines scenario* cuts the baseline peakflow magnitude in half and doubles the duration of the peakflow release. The *steady baseflow scenario* releases a constant non-peaking flow. This scenario releases a discharge 3.7 to 7.3 times greater (depending on season) than is presently released in order to account for the average seasonal inflow into the reservoir. This increase in baseflow is within the recommend range to maximize available habitat for all life stages of brown trout in the Smith River (USFWS 1986).

Table 1. Characteristics of the baseline and alternative flow scenarios. The peakflow, release duration, and release time were not applicable (NA) to the steady baseflow scenario.

Season	Scenario	Peakflow (m^3/s)	Baseflow (m^3/s)	Release Duration (hrs)	Release Time	Outflow Temp. (°C)
Spring	Baseline	31.3	1.4	6	7:00	7
	12°C Outflow	31.3	1.4	6	7:00	12
	New Turbines	15.6	1.4	12	7:00	7
	Steady Baseflow	NA	10.2	NA	NA	7
Summer	Baseline	31.8	1.5	5	14:00	9
	12°C Outflow	31.8	1.5	5	14:00	12
	New Turbines	15.9	1.5	10	14:00	9
	Steady Baseflow	NA	5.5	NA	NA	9

Thermal Preferences of the Roanoke Logperch

We reviewed literature to determine the extent of knowledge concerning thermal preferences of the Roanoke logperch (*Percina rex*), as well as related species (i.e. *Percina caprodes, Percina burtoni*). In addition, we contacted several investigators familiar with the life history of the Roanoke logperch.

Roanoke logperch were collected and identified during one week in June (summer) over a three-year period (2000, 2001, and 2002) and one week in April (spring) over a two-year period (2001, 2002) in the Smith River tailwater. Fish were collected at 12 study sites representing the longitudinal gradient of the tailwater (Figure 1). Sampling was performed via electrofishing a 100m blocked section with a three-pass depletion method. Using the temperature modeling methodology described above, temperatures were modeled for each of the 12 sampling sites in the tailwater for the month of April during the years 2001 and 2002 and during the month of June in the years 2000, 2001, and 2002.

A presence-absence matrix was developed to determine at which study sites Roanoke logperch were present or absent during each sampling event. A monthly average water temperature was computed for each of the twelve sites during the month the sampling occurred. To derive a lower thermal threshold for presence, the lowest average temperature at sites where logperch were present was computed for all years during the two seasons sampled.

Results

Temperature Predictions under Baseline and Alternative Scenarios

The 12°C outflow scenario provided the greatest increase in occurrence of 12-19°C temperatures during spring and summer by 50% and 25% over baseline conditions throughout the tailwater, respectively (Table 2). The improvement in water temperature from the 12°C outflow scenario was greatest in the upper section (0.0-5.3 km) of the tailwater (Figure 2), where occurrence of 12-19°C temperatures increased from 0% to 60% in spring, and 9% to 100% in summer (Table 2). Scenarios involving modern turbines (the new turbine and steady baseflow scenario) caused little to no improvement of optimal growth temperatures (Table 2). None of the scenarios caused water temperature to exceed the Department of Environmental Quality maximum 21°C standard during any season, with the exception of the 12°C outflow scenario, which only caused a 1% exceedance in the lower section (10.0-24.3 km) during summer (Table 2). During summer, the steady baseflow scenario caused the largest decline (up to 3°C) in diurnal flux (Table 2). Minimal to no change occurred for spring. Hourly declines in temperature only exceeded the DEQ 2°C standard in summer and the steady baseflow scenario caused the greatest reduction of MHTD (1-4°C). The 12°C outflow scenario was the only scenario able to elevate the average temperature from baseline conditions during spring and summer (Table 2). The increase in average temperature was greatest in the upper section (Figure 2); 4°C increase in spring and 3°C in summer.

Table 2. Temperature predictions for baseline conditions and alternative scenarios shown as percent time temperature was within 12-19°C, percent time 19°C & 21°C was exceeded, diurnal flux (°C), maximum hourly temperature decline (MHTD °C), and average temperature (°C). Values are averages for a one week period (Tuesday-Monday) from 0.5 to 23.7 rkm below Philpott dam by season. In parenthesis are model predictions averaged within the upper, trophy trout managed, and lower section of the tailwater.

Season	Scenario	%12-19°C	% >19°C & <21°C	%>21°C	Diurnal Flux (°C)	MHTD (°C)	Avg. (°C)
Spring	Baseline	10 (0,7,15)	0 (0,0,0)	0 (0,0,0)	3 (3,4,3)	1 (0,1,2)	10 (8,10,11)
	12°C Outflow	60 (60,47,64)	0 (0,0,0)	0 (0,0,0)	3 (3,4,2)	0 (0,0,0)	12 (12,12,12)
	New Turbines	10 (0,7,15)	0 (0,0,0)	0 (0,0,0)	3 (2,3,2)	1 (0,1,1)	9 (7,9,10)
	Steady Baseflow	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)	3 (2,3,3)	0 (0,0,0)	9 (7,8,9)
Summer	Baseline	55 (9,76,68)	14 (0,0,24)	0 (0,0,0)	6 (3,6,7)	3 (2,3,4)	14 (10,14,16)
	12°C Outflow	80 (100, 96,66)	20 (0,4,33)	0 (0,0,1)	5 (3,5,6)	2 (1,3,3)	16 (13,15,17)
	New Turbines	50 (10,63,64)	14 (0,0,25)	0 (0,0,0)	6 (3,7,7)	2 (1,3,2)	14 (10,13,16)
	Steady Baseflow	64 (4,40,97)	0 (0,0,0)	0 (0,0,0)	3 (2,4,3)	0 (1,1,0)	13 (10,12,15)

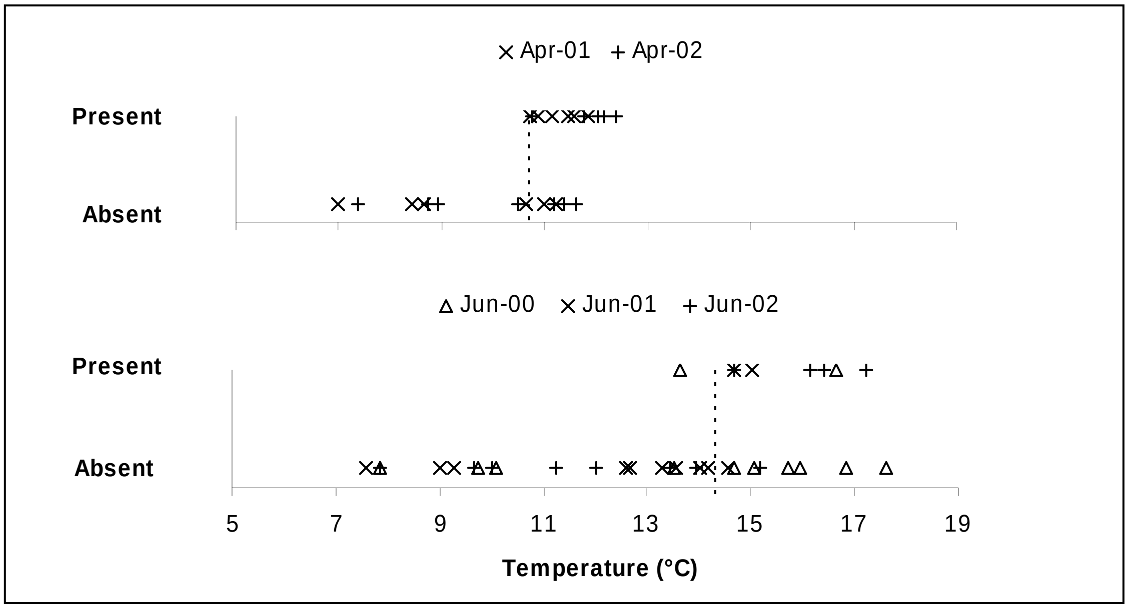


Figure 2. Presence-absence of Roanoke logperch along a temperature gradient for April (spring) and June (summer). The dashed line indicates the lower threshold temperature presence value. No sites were sampled at higher temperatures.

Thermal Habitat for Smith River Fish Species under Alternative Scenarios

Given Roanoke logperch presence-absence information, as well as average temperatures, a threshold temperature value for presence was determined for spring (10.73°C) and summer (14.34°C) seasons (Figure 2). During spring, the12°C outflow scenario provided substantial improvement, increasing the logperch's potential range to include the entire tailwater (Figure 3). During summer, the 12°C outflow scenario predicts the greatest potential increase of logperch presence throughout the tailwater, by increasing water temperatures above the threshold value at 5 km rather than 10 km (Figure 3).

Assuming that the growth of brown trout in the Smith River tailwater would improve under an increased occurrence of optimal growth temperatures (12-19°C), only the 12°C outflow scenario provided improvement in all reaches during spring, and the dam reach in summer (Figure 3).

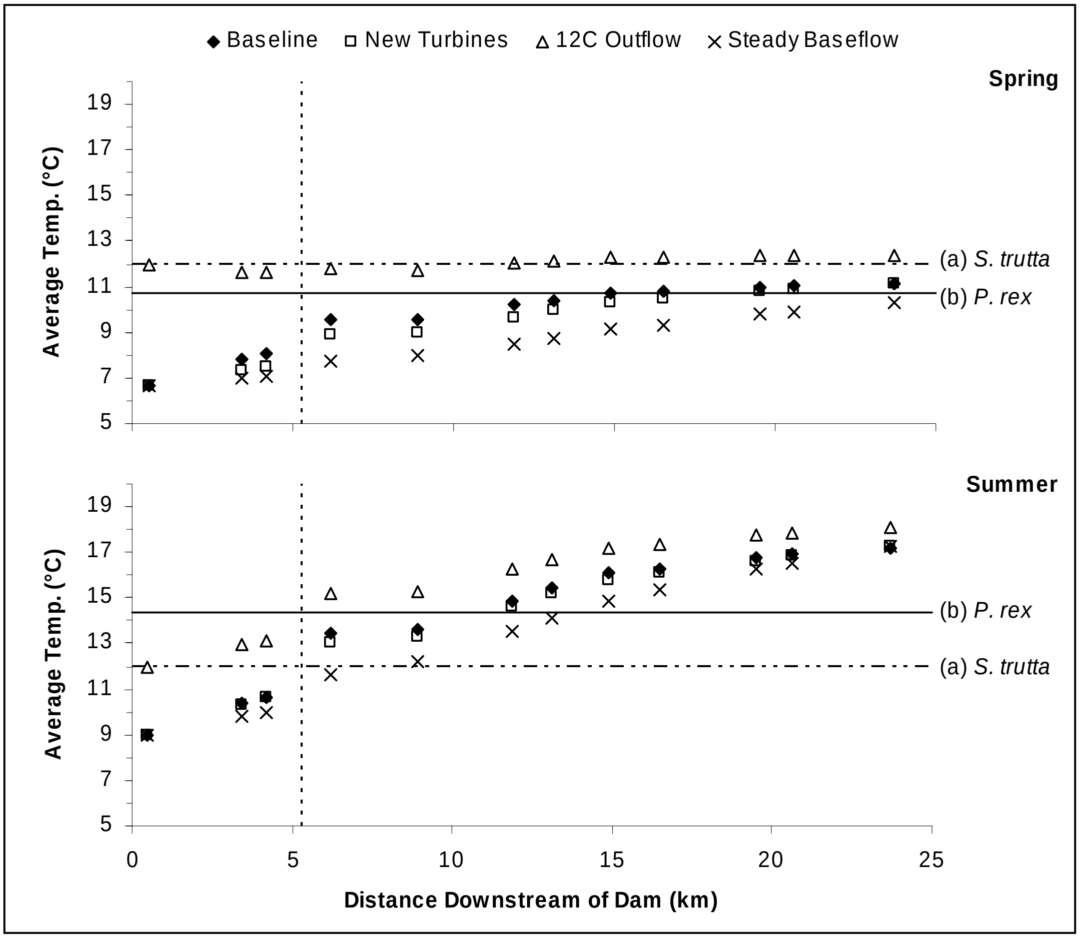


Figure 3. Spring and summer average temperature predicted under alternative flow scenarios in relation to distance downstream of Philpott Dam. Horizontal lines represent (a) the lowest optimal growth temperature for brown trout (*S. trutta*) and (b) the threshold temperature presence value for Roanoke logperch (*P. rex*). The vertical dashed line indicates the location of Town Creek.

Discussion

These results show that the effective management of trout and endemic warmwater species in hydropeaking tailwaters are not necessarily mutually exclusive. In addition, our study emphasizes the importance of deliberate, informed flow management to alter the ichthyofauna of tailwaters.

The Smith River is a tailwater fishery that holds possibilities for improvement. Many authors have emphasized the importance of water temperature upon growth and survival of fish (Fry 1971; Hinz 1998; Ojanguren 2001). Our study suggests that slightly altering the temperature of peaking releases may provide a greater physiological potential for growth among the naturalized brown trout. Additionally, this flow scenario requires no change in peaking operations, allowing the controlling agency to continue meeting hydroelectric energy demands (Krause et al. in press).

Water temperature also strongly influences the patterns of distribution of stream fishes (Matthews and Styron 1981; Matthews 1987; Hawkins et al. 1997). In addition to improving the conditions for trout growth, our predicted alternative flow scenario may also increase the habitable area of the tailwater for the endangered Roanoke logperch. Logperch have been observed to spawn during mid-April to early May in waters between 12 and 14°C (Burkhead 1983; Jenkins and Burkhead 1993). Our results show that during April, a 12°C outflow scenario would permit suitable spawning temperatures to pervade the entire tailwater, thereby significantly increasing the chance of spawning success. This scenario may provide an additional benefit to the conservation of Roanoke logperch in the Smith River tailwater. Jenkins and Burkhead (1993) indicate that two populations of Roanoke logperch exist within the vicinity of the tailwater. One population occupies downstream reaches of the mainstem; the other inhabits Town Creek, thermally isolated from the mainstem population. Our 12°C outflow scenario predicts that temperatures would become suitable for Roanoke logperch upstream of Town Creek, allowing for the spatial connection of two previously isolated habitats.

Roanoke logperch are often classified as a warmwater stream fish (Burkhead 1983; Jenkins and Burkhead 1993; A. Rosenberger, University of Idaho, pers communication). Conditions that increase the potential range of the logperch may also increase the range of other warmwater nongame fish in the tailwater. Releasing the spatial restrictions of nongame fish imposed by the current temperature regimen may provide an indirect benefit to brown trout in the tailwater by increasing the forage available to them.

We assume that increased water temperatures result in increased trout growth. Continuing studies on the Smith River tailwater using bioenergetics modeling and *in situ* sampling will determine whether increased temperatures do in fact enhance trout growth. Additionally, we concede that the life history and true temperature preferences of the Roanoke logperch are not yet well known (especially summer optimum). Due to small populations and low densities, our data on logperch are limited. Finally, realistic changes in flow management to enhance both the economic and ecological integrity of the tailwater require a significant initial investment of time and resources, and the cooperation of agencies.

Acknowledgements

This study was funded by the Virginia Department of Game and Inland Fisheries and the US Fish and Wildlife Service Federal Aid in Sport Fish Restoration program (contract # F-121-R). The authors thank T. Newcomb for manuscript editing and G. Hauser for assistance with the ADYN & RQUAL model development. We would also like to thank the VDGIF staff for sampling assistance.

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Research and Management of Rainbow/Steelhead Populations in the Kalama River, Washington: A Smorgasbord of Life History Forms, Regulations, and Fishing Opportunities

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ABSTRACT—Evolutionary forces and human intervention have produced a variety of stocks and life history forms of rainbow trout (*Oncorhynchus mykiss*) in the Kalama River, Washington. There are indigenous populations of anadromous steelhead in both summer and winter run forms, as well as a resident (non-anadromous) population with unknown ecological and phylogenetic relationships to the anadromous forms. Added to that mix to bolster recreational fisheries throughout the last half century are summer and winter run forms of artificially propagated steelhead of non-local stock origins. Finally, artificially propagated summer and winter steelhead spawned from the local wild stocks have been introduced for the past several years to evaluate the efficacy and risks associated with that alternative form of hatchery production. Ongoing research of Kalama steelhead have provided some insights regarding the often competing goals of wild stock conservation and hatchery stock utilization. Evidence confirms some suspected risks, but also suggests some measure of success in achieving those goals in the Kalama. Successful conservation of the anadromous and resident wild populations, while providing diverse recreational fisheries was aided by a number of factors, including: natural habitat features, management actions, biological attributes of the fish, and good fortune.

Introduction

Concurrent management of sympatric resident and anadromous forms of *Oncorhynchus mykiss* (rainbow trout and steelhead) poses challenges. For example, management objectives and fishing regulations for the two forms may conflict, such as when incidental catch in trout fisheries impacts the survival of juvenile steelhead. Incomplete understanding of the biology and population structure of the two life history forms increases the challenge (Kostow 2004). Another layer of complexity is added in the case of the Kalama River in southwest Washington, which has sympatric indigenous populations of both summer and winter run forms of steelhead. The complexity increased another notch when non-local origin hatchery stocks of both summer and winter run forms were introduced in the 1950s to provide more sport harvest. Recently, two additional hatchery stocks of "wild broodstock" steelhead have been added. The two new stocks were spawned from adults of the indigenous wild summer and winter populations, to achieve both research and sport harvest objectives (Sharpe et al. 2000; Hulett et al. In press). Research conducted on Kalama steelhead since 1975 has provided considerable information on the biology and population interactions among the indigenous wild stocks and the transplanted hatchery stocks. That information helped guide decisions on Kalama steelhead management, which aims to provide harvest of hatchery fish while also achieving wild stock conservation objectives. Despite the complicated mix of stocks and life history types involved, the Kalama continues to support one of the few relatively healthy wild summer-run populations in western Washington, as well as a robust wild winter-run population. In this paper, we describe the elements of past management decisions, research information and objectives, river basin traits, fish population attributes, and even some luck, that all played a role in the development and success of steelhead management strategies used in the Kalama.

Background

The Kalama River drains an area of 531 km^2, flowing westerly from headwaters on the southwest flanks of Mount St. Helens to its confluence with the lower Columbia River at river km 117 (Figure 1). Populations of both summer-run and winter-run steelhead as well as non-anadromous rainbow trout are endemic to the Kalama, as are *Oncorhynchus clarki* (cutthroat trout), *Oncorhynchus tshawytscha* (chinook salmon), and *Oncorhynchus kisutch* (coho salmon). Returning adults from the summer-run steelhead population enter the river from April through December (July peak) and over-winter in the upper Kalama basin prior to spawning in the late winter and spring. In contrast, the winter-run population enters the river from November to early June (April peak) just prior to spawning in late winter and spring. Beginning in the late 1950s, hatchery summer and winter steelhead of non-local stock origin were transplanted annually to the Kalama from two hatcheries located on other lower Columbia River tributaries. The hatchery summer-run fish were from Skamania Hatchery on the Washougal River and had broodstock origins from of native Washougal and Klickitat Rivers. The hatchery winter-run fish were from Beaver Creek Hatchery on the Elochoman River and had broodstock origins from multiple sources (Crawford 1979) including the Elochoman River, Chambers Creek Hatchery (southern Puget Sound) and Cowlitz Hatchery (Figure 1). Traditionally, there were no hatchery steelhead reared in the Kalama basin, as Kalama facilities were focused on salmon production. A fishway and trap adjacent to a barrier falls at Kalama Falls Hatchery (river km 17) provides access to upstream migrant salmonids in the Kalama River. Except in recent years (explained later), all steelhead (hatchery or wild) collected in the trap since 1976 have been enumerated and passed upstream. Summer-run steelhead are able to jump the barrier falls during low flow months of May to September, resulting in approximately 50% of the run bypassing the fishway by jumping the falls (Bradford et al 1996).

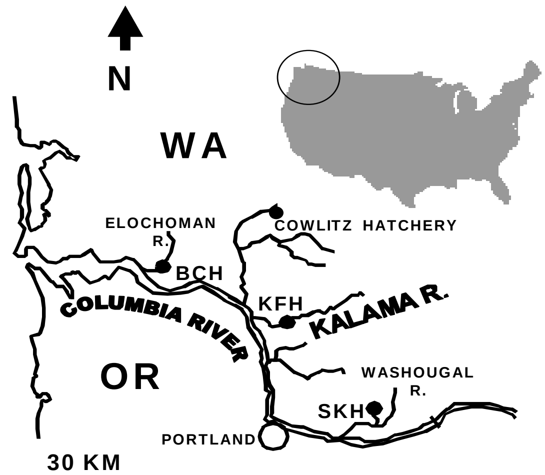

Figure 1. Location of the Kalama River and Kalama Falls Hatchery (KFH) in the lower Columbia River drainage in relation to Beaver Creek Hatchery (BCH) on the Elochoman River, Cowlitz Hatchery on the Cowlitz River, and Skamania Hatchery (SKH) on the Washougal River.

Adaptive Management

Early Years

The combination of the hatchery and wild summer and winter stocks returning to the Kalama provided a popular steelhead fishery, with adult fish present in the river year-round. The hatchery winter-run stock (selected for early return and spawn timing) provided an early winter fishery while the wild winter-run returns peaked in April and continued through May. The hatchery and wild summer-run both provided harvest opportunity from May through the fall. While the hatchery stocks were managed solely to provide harvest, the wild stocks were managed to achieve wild escapement goals and their abundances were tracked separately. This separate management of the hatchery and wild stocks helped both to maximize harvest on the hatchery stocks, and to permit annual abundance estimates of the wild populations. In addition, the early run timing of the hatchery winter-run permitted a focused fishery on that stock and helped minimize inclusion of hatchery fish in spring wild winter-run spawner surveys. All these factors contributed to the ability to separately enumerate and manage the hatchery and wild stocks.

Fishery regulations implemented decades ago, coupled with some features of the Kalama basin, provided extra protection to the wild stocks. Key among these was the creation of a closed waters (no fishing) sanctuary in the upper watershed. Though boundaries were changed somewhat over the years, the current sanctuary extends from river km 34 to river km 59 where Upper Kalama Falls blocks upstream fish passage. This 25 km closed section represents over 40% of the anadromous zone of the Kalama River (Figure 2).

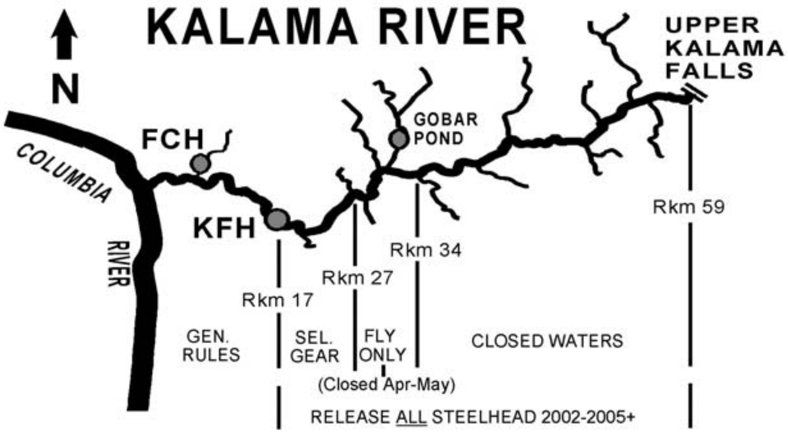

Figure 2. The anadromous portion of the Kalama River basin from the mouth to the impassible Upper Kalama Falls. Fish rearing facilities shown are Fallert Creek Hatchery (FCH), Kalama Falls Hatchery (KFH), and Gobar Pond, an earthen rearing pond on Gobar Creek. Also shown are the four sections with differing fishing regulations as described in the text.

Immediately below the closed waters is a 7 km stretch that was designated as a fly-fishing only section more than 50 years ago (originally including the stretch from river km 17-27 as well). Though that section has long been popular and well known as the “Holy Water” among fly fisherman, it has tended to receive less pressure in recent years than lower sections of the river.

Another factor that increases the benefit of the upper river sanctuary is the water temperature influence of cold springs in the upper basin. The primary headwater source of the Kalama River is Kalama Spring, a cold springs which bubbles up out of the volcanic rock on the lower flanks of Mount St. Helens. There are also numerous smaller cold springs that add to the cold flow input around and above the upper falls area. The collective effect of these cold water sources can result in mainstem Kalama River water temperatures near the upper falls being up to 9 ˚C colder than at Kalama Falls Hatchery (KFH). Furthermore, the mean daily water temperatures at the upper falls only varied from 4 to 9 ˚C over the whole year, as opposed to a range from 1 to 17 ˚C at KFH (Figure 3). Thus, the upper basin has more favorable late summer water temperatures than are found in the lower basin. Also, during extreme cold periods (see early January in Figure 3), the upper basin water temperatures were warmer (4 ˚C) than at Kalama Falls Hatchery (1 ˚C).

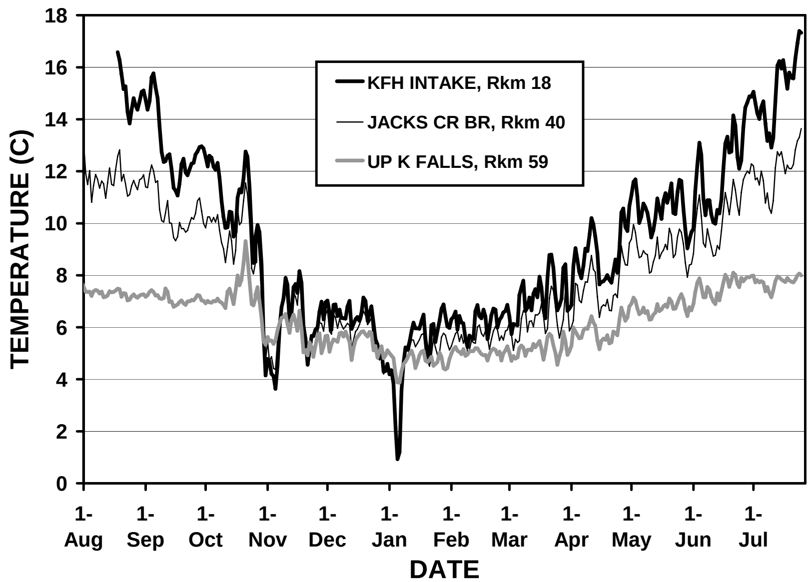

Figure 3. Mean daily water temperatures of the mainstem Kalama River at three sites from Kalama Falls Hatchery to Upper Kalama Falls, from August 2003 through July 2004. As discussed in the text, the upper site is heavily influenced by cold spring water sources, while the lower sites are more influenced by ambient air temperature and surface runoff sources that are generally warmer than the spring water.

Harvest Restrictions

A major change in Kalama steelhead management in more recent decades was the implementation in 1986 of wild steelhead release regulations for Kalama wild summer-run. This was followed by similar release requirements for the winter-run in 1991, as both stocks were failing to regularly meet their established escapement goals of 1000 adults each. Harvest on wild fish, which had ranged from 700-1600 adults for the summer-run (1982-1985) and from about 200-1600 adults for the wild winter-run (1983-1990), was thus reduced to near zero (compliance is not 100%) following the regulation change (Figure 4).

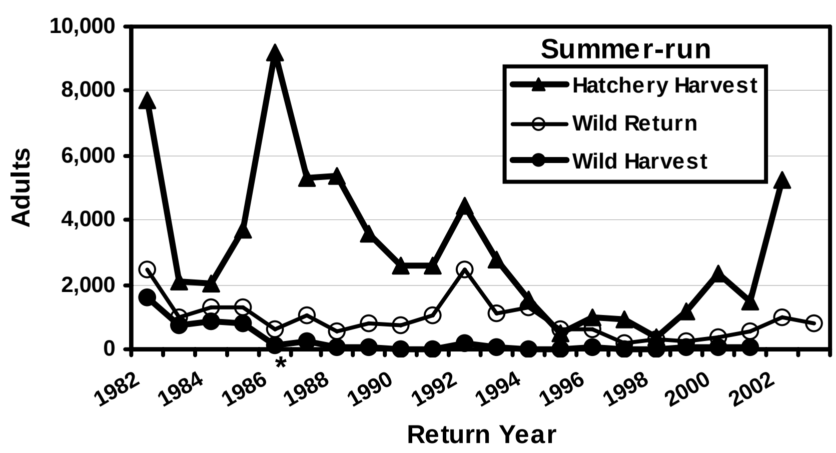

Figure 4. Angler harvest of hatchery and wild summer steelhead, and total returns of wild summer steelhead, in the Kalama River from the 1982 through 2003 summer-run return years. Regulations requiring the release of wild steelhead were implemented in 1986, marked by an asterisk on the return year axis.

Despite this conservation action, wild summer-run returns did not increase notably following implementation of the wild release regulation, apart from one good return year in 1992. Poor ocean survival conditions through the rest of the 1990s led to a steady decline culminating in all-time low returns of 200-300 wild summer-run from 1997 to 1999. That was followed by improved ocean survival conditions and gradual rebuilding to return levels of about 1000 and 800 in 2003 and 2004, respectively (Figure 4). The lack of increase in numbers should not be interpreted as a failure of the wild release regulation. Rather it emphasizes the importance of the regulation: had harvest been allowed during those years of low returns, the spawning escapements would have been reduced even further (wild harvest rates averaged over 65% from 1983 to 1985).

Winter-run returns followed a similar pattern, but with a less precipitous decline ending in lows near 500 fish from 1997 to 1999. However, the winter-run recovered more quickly following the return to favorable ocean conditions, increasing from 500 to over 2100 in five years (Figure 5).

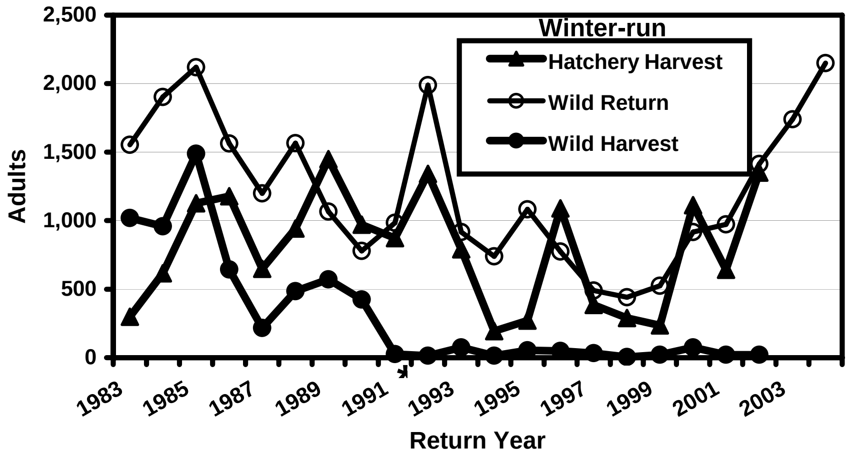

Figure 5. Angler harvest of hatchery and wild winter steelhead, and total returns of wild winter steelhead, in the Kalama River from the 1983 through 2004 winter-run return years. Regulations requiring the release of wild steelhead were implemented in 1991, marked by an asterisk on the return year axis.

Hatchery-Wild Interactions

The next major change in the management of Kalama steelhead involved reducing the risk of negative interactions between the wild stocks and the non-local origin hatchery stocks. The question of whether naturally spawning hatchery fish posed genetic risks to the wild populations was formally posed in a report commissioned by the Washington Department of Game to review its hatchery program (Royal 1972). Research conducted on the Kalama River for the next two decades evaluated the reproductive success of the hatchery stocks relative to the wild Kalama stocks spawning naturally in the Kalama River. Those studies concluded that while the hatchery fish contributed substantial numbers of naturally produced juvenile offspring, their production of returning adult offspring (per adult spawner) was considerably lower than that of wild Kalama adults (Chilcote et al. 1986; Leider et al. 1990; Campton et al. 1991; Hulett et al. 1996). Other work found that hatchery and wild fish would likely interbreed to some degree, as the populations were only partially reproductively isolated by time and place of spawning (Leider et al. 1984).

These findings suggested that naturally spawning hatchery stocks posed ecological and genetic risks to wild fish. To reduce those risks, efforts began in 1997 to exclude returning adults of the non-local hatchery stocks from key wild steelhead spawning and rearing habitat, above Kalama Falls Hatchery. A flexible plastic mesh curtain was hung from cable over the top of the falls (Figure 6) during the summer months to prevent fish from jumping the falls (Sharpe et al. 2000).

All wild adults from the trap were passed upstream, and summer-run were given a pink Floy® tag for visual identification during late summer snorkel surveys. In 1997, 500 hatchery summer-run were passed upstream as a consolation to the upriver fishery. In subsequent years, all hatchery adults were marked (by colored tags or a caudal punch) and trucked to downstream release sites to reenter the lower river fishery. In early September the entire mainstem Kalama above KFH was surveyed by snorkelers to assess the efficacy of the barrier by estimating the number of successful “jumpers” (jumpers would have no tag, or a tag of a color other than pink). The result was a very high reduction in the upstream escapement of hatchery summer-run, and a virtual elimination of hatchery winter-run escapement upstream (Figure 7).

Temporary loss of the mesh curtain during flow events in some years permitted moderate numbers of adults (<200) to bypass the fishway until the mesh was replaced. A more serious failure occurred in 2003 when a small passage way opened up through interstitial spaces between boulders in a rock bank at one side of the falls and nearly 700 hatchery fish passed upstream by that route. Despite the setbacks, the escapement of hatchery summer-run was reduced from an average of over 2300 from 1982-1996 to less than 240 from 1997-2003. Because hatchery winter-run are not successful at jumping the falls (Bradford et al. 1986), we presume the passage denial of those fish to be 100% effective (winter conditions preclude confirmation by snorkel surveys).

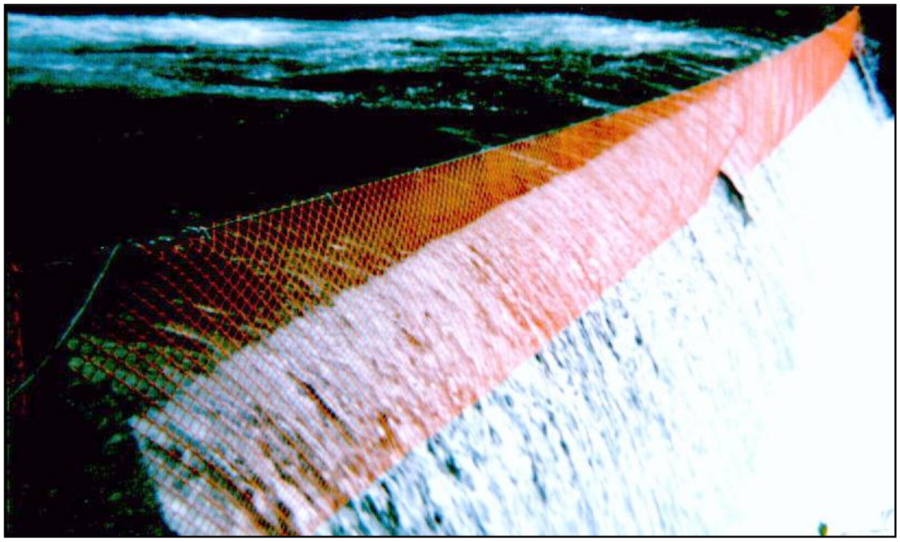

Figure 6. Plastic “construction barrier” mesh suspended from cable over the top of the partial barrier falls below Kalama Falls Hatchery to prevent summer steelhead from jumping the falls and bypassing the fishway. The entrance to the fishway would be directly below the lower left corner of the photograph.

Given the number of years in which hatchery adults had high levels of spawning escapement (Figure 7), some level of genetic introgression from the hatchery stocks into the wild populations might be expected. However, genetic analyses of the 1988-1993 brood years of the hatchery and wild stocks showed relatively discrete population structure based on allozyme profiles (Sharpe et al. 2000). While those data should not be construed as evidence that the wild stocks remain genetically "pure", they do suggest that a combination of factors acted to avert homogenization in spite of the high potential for gene flow. Two factors that could have reduced gene flow are the partial reproductive isolation due to earlier spawn timing of the hatchery stocks (Leider et al. 1984) and the greatly reduced ability of the hatchery stocks to produce returning adult offspring relative to that of the wild stocks (Leider et al. 1990; Hulett et al. 1996).

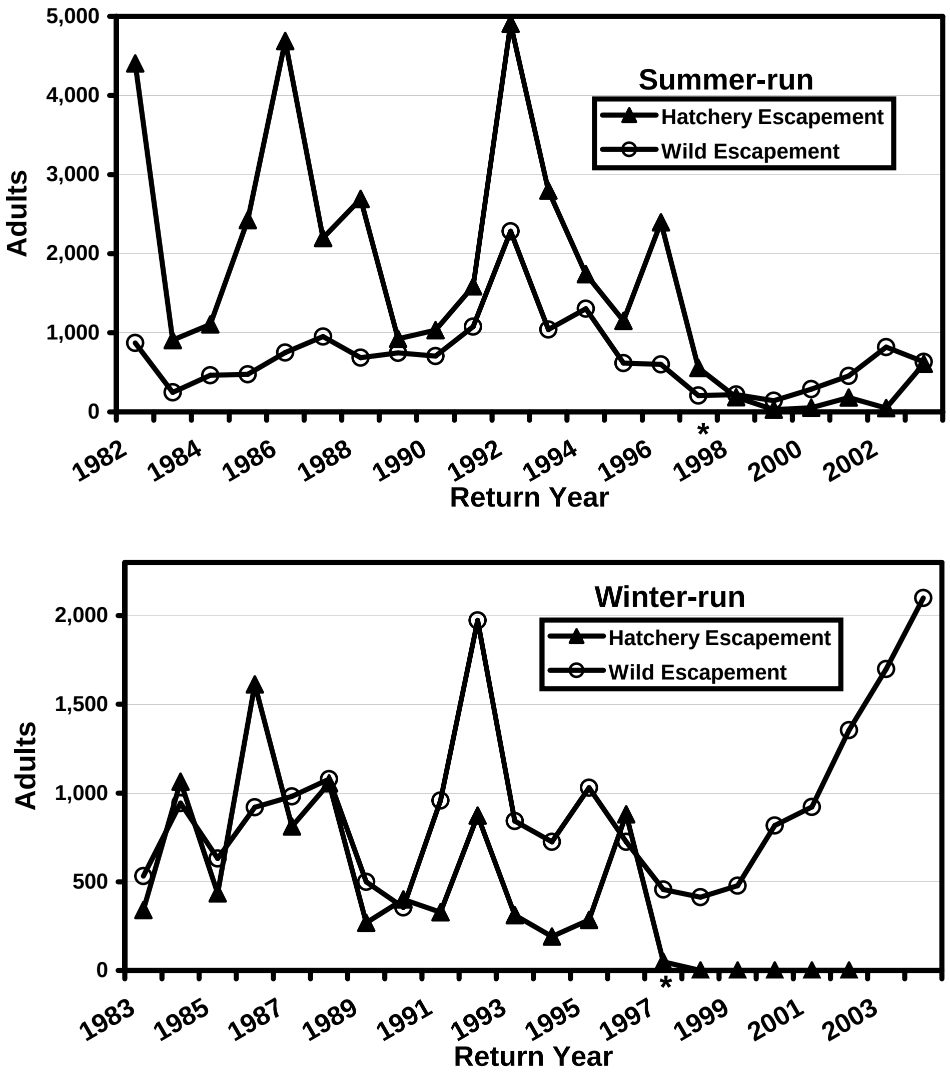

Figure 7. Spawning escapement of summer-run (top panel) and winter-run (bottom panel) steelhead above Kalama Falls Hatchery for the 1982-2003 summer-run and 1983-2004 winter-run return years. Asterisks on the return year axes mark the cessation of passage of hatchery adults above the hatchery in 1997.

Wild Broodstocks

The production and evaluation of steelhead wild broodstock hatchery programs on the Kalama River is the most recent change in management strategies of Kalama steelhead. Summer-run and winter-run programs were both initiated in 1998, and have resulted in five years of smolt releases for summer-run (2000-2004) and six for winter-run (1999-2004). The main impetus for these programs was to rigorously assess the efficacy and risks of using local wild broodstock for hatchery steelhead programs (see Sharpe et al. (2000) and Hulett et al. (in press) for program details). However, both programs also provide harvest in addition to that from the ongoing hatchery programs using the traditional non-local origin stocks. The addition of these stocks affect management and fisheries in the Kalama in a number of ways, including fish passage protocols, harvest regulations, and fishery characteristics.

The primary objective of the summer-run wild broodstock program is to compare the reproductive success of its returning adults to that of the wild Kalama adults when both spawn naturally in the Kalama River. The experimental design calls for equal numbers of wild broodstock hatchery adults and wild adults to be passed upstream of Kalama Falls Hatchery. However, those two groups of fish must have equal opportunity to spawn for the comparison of their reproductive success to be biologically meaningful. Thus, because of the research needs, we implemented an unusual regulation that requires the release of all steelhead (including hatchery adults) caught in the mainstem and tributary waters above Kalama Falls Hatchery. However, all hatchery steelhead are still subject to harvest in the lower river, and wild broodstock returns in excess of those needed to match wild numbers passed upstream are “recycled” downstream to reenter the fishery.

Adults from the winter-run wild broodstock program that return to the trap at Kalama Falls Hatchery are all trucked downriver to be passed through the lower river fishery again, similar to the protocol for the non-local hatchery stocks. Because the wild stock has a much later return time than the non-local winter stock, the duration of the winter-run fishery is greatly extended by the addition of the wild broodstock component. The fishery on the non-local stock is conducted mainly in December and January, whereas the wild broodstock program contributes to harvest from February into May.

Another feature of the summer-run wild broodstock evaluation is the need to understand whether or to what extent resident rainbow trout contribute to the production of anadromous *O. mykiss* in the Kalama River. Other studies of reproductive success have found that surprisingly large numbers of returning anadromous adults do not appear to have come from the anadromous parents that previously spawned in that basin (e.g., Blouin 2003). The working hypothesis is that resident rainbow trout may be contributing to the production of anadromous offspring. In an attempt to test that hypothesis, we are collecting tissue samples for DNA analyses that could tell us if any of the sampled resident fish were a parent to any of the anadromous fish we sample to conduct the reproductive success study. Based on observations during snorkel surveys, it appears that the majority of the resident trout are found in the upper basin (closed waters), so they may not contribute much directly to fishery benefits. They may, however be an important component of the overall life history diversity of *O. mykiss* in the Kalama, and perhaps contribute to the stability and persistence of the anadromous population.

Summary

Through several decades of changes in management approaches, the Kalama River continues to support productive and popular harvest fisheries on hatchery steelhead, as well as relatively healthy wild populations of steelhead and resident rainbow trout. Factors believed to contribute to this success include: the intent and ability to manage and monitor hatchery and wild stocks separately, the provision of closed water sanctuary habitat, the ability to control the distribution of returning hatchery adults, and a comparative wealth of information on the biology of the local populations due to rigorous monitoring and evaluation. A healthy dose of good fortune also came into play, in that the wild steelhead stocks maintained genetic distinctness despite the many generations of potentially disastrous hatchery introgression from non-local, domesticated stocks.

Acknowledgements

We thank the crew and supervisors of the Kalama Falls Hatchery for their support and patience in dealing with the meddling of biologists on the hatchery grounds. This work was supported by Mitchell Act funding administered by NOAA Fisheries in cooperation with the Washington Department of Fish and Wildlife.

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Apache Trout—Restoration, Recreational Fisheries, and Species Recovery

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ABSTRACT— The Apache trout is listed as threatened under the Endangered Species Act (ESA). Past recovery efforts have led to improvement in Apache trout populations in the White Mountains and on the lands of the White Mountain Apache tribe in eastern Arizona. In 2003, the U.S. Fish and Wildlife Service (USFWS), White Mountain Apache Tribe (WMAT), U.S. Forest Service (USFS), Arizona Game and Fish Department (AGFD), and Trout Unlimited formed an informal Apache Trout Recovery Partnership (Partnership) to fund and implement conservation work. While many restoration projects for Apache trout have occurred over the past 35 years, the recent efforts of the Partnership have focused on an approach that combines species recovery concerns with a long term goal of developing robust Apache trout recreational fisheries. The Partnership's conservation actions are guided by the Apache Trout Recovery Plan (USFWS 1983) developed by the Apache Trout Recovery Team (Recovery Team) pursuant to the ESA listing for the species. A revision of the Recovery Plan is in draft format, and is expected to be released in the Federal Register in 2005. In conducting current Apache trout restoration activities and in planning future activities, both the members of the Recovery Partnership and the Recovery Team are addressing issues that require balancing native trout recovery activities and the management of recreational fisheries based on introduced trout species. This paper provides an overview of Apache trout restoration efforts and the implications for recreational fisheries in the future.

Introduction

The Apache trout, one of the first native fish to be placed on the federal Endangered Species Act (ESA) list, is an important part of Arizona's natural heritage and recreational fisheries. Many species conservation activities have occurred over the last 35 years. In 2003, the U.S. Fish and Wildlife Service (USFWS), White Mountain Apache Tribe (WMAT), U.S. Forest Service (USFS), Arizona Game and Fish Department (AGFD), and Trout Unlimited formed an informal Apache Trout Recovery Partnership (Partnership) to fund and conduct conservation work. The Partnership is supported by a national grant from the National Fish and Wildlife Foundation which is matched by state and local resources (non-federal dollars and/or in-kind services). The work conducted by the Partnership under the grant has direct implications for restoring depleted and extirpated fish populations, de-listing the species under the ESA, and developing robust recreational fisheries.

The grant work is guided by a recovery plan for Apache Trout (USFWS 1983) authored by a Recovery Team pursuant to the ESA listing. The Partnership has used the recovery plan to guide implementation of recovery projects and to address many of the issues that are common to the balancing of native trout recovery and introduced trout that support recreational fisheries.

Species Description and Threats

The Apache trout is a native species found only in Arizona. These golden fish, with olive-green back and dorsal fins and sparse black spotting, inhabit the streams of the White Mountains. Although still formally identified as a separate species (Oncorhyncus apache), the Apache trout will likely soon be identified as a subspecies of Gila trout by the American Fisheries Society due to their close evolutionary relationship (Joseph Nelson, Committee on Names of Fishes, personal communication). Both Apache and Gila trout are more closely related to rainbow trout than to cutthroat trout, and probably represent the earliest living branch of ancestral trout associated with the Gulf of California. These ancestral trout are believed to have ascended the Gila River Basin via the Colorado River about 500,000 to 1 million years ago (Behnke 2002).

The maximum known age for Apache trout is 6 years. Most fish reach maturity in three years (6 to 9 inches). Native populations are presently restricted to clear, cool, high-elevation mountain streams that flow through meadows and coniferous forests, upstream from natural and man-made barriers. The fish may grow much larger (up to 24 inches and 6 pounds) when introduced in lakes rather than in their small stream habitat. Natural lakes were in the historic range of the species. The current lake dwelling populations were developed to support recreational fisheries only.

In the late 1800s, substantial harvest of Apache trout was documented in its historical stream range. The impacts of human settlement rapidly eliminated or reduced most populations within a span of about 50 years (Behnke and Zarn 1976; Harper 1978). By the time the subspecies was officially described and then listed under the ESA in the 1970’s, the Apache trout was found in fewer than 30 miles of the 600 miles of stream that it originally occupied on the Fort Apache Indian Reservation and the Apache-Sitgreaves National Forest (Carmichael et al. 1993). Although the exact historic distribution of the Apache trout is not known for certain, there is no doubt that widespread introduction of brook, brown, and rainbow trout and loss of habitat due to land-use practices including livestock grazing, logging, road construction, and water diversions drastically affected their former native range (Behnke 2002). Although many of the threats have been addressed, further conservation work remains to fully restore the species and perhaps modify Apache trout recreational fisheries today.

Road to Recovery

Apache trout recovery involves a variety of actions including construction of fish barriers to prevent encroachment of non-native species, improvement of riparian habitats, control of livestock use, removal of non-native fish, and reintroduction of populations to historic stream habitats (Springer 1999). These actions are typical of similar native fish efforts in many other areas. While the species is probably more secure and there are more recreational fishing opportunities for Apache trout than when it was first listed, the improvements occurred at an uneven rate over many years. A brief timeline developed by AGFD provides a glimpse of the challenges faced by the trout and those who have worked to restore them:

1940s-1950s - White Mountain Apache Tribe initiated Apache trout conservation efforts when the only known populations existed on the Fort Apache Indian Reservation. On March 24, 1955 the tribe closed all streams within the boundaries of the Mount Baldy Wilderness Area to fishing. Subsequently, other streams deemed important to Apache trout conservation were also closed to fishing.

Early 1960s - Fishery surveys were conducted by the USFWS and the AGFD in cooperation with the WMAT to determine the Apache trout status. A controlled propagation program was initiated as part of the federal and state Apache trout recovery effort in 1963. During this period, fish barriers were constructed on several streams to prevent upstream migration of non-native trout. Several streams were renovated to remove non-native rainbow trout, brown trout, and/or brook trout. Pure Apache trout were stocked into streams following renovations.

1966 - Despite early conservation efforts, Apache trout were considered endangered under the Federal Endangered Species Preservation Act of 1966 and became federally protected with passage of the Endangered Species Act in 1973.

1975 - The Apache trout was one of the first species to be down-listed from endangered to threatened after re-evaluation of its status. The down listing included a 4(d) rule that allows the State to authorize selective angling opportunities. Hatchery-reared fish were stocked to establish angling opportunities.

1979 – A recovery team consisting of federal, state, and tribal agencies prepared an initial recovery plan for Apache trout pursuant to the ESA listing. The plan was updated in 1983.

1983-87 – The Old Pueblo Chapter of Trout Unlimited obtained private sector national grants and undertakes habitat restoration activities in the Black River watershed to aid Apache trout recovery.

1994 - The AGFD in cooperation with the USFS developed a habitat improvement plan to install approximately 30 miles of riparian fencing to protect key stream segments from livestock and/or elk damage.

2002 – 2004 -The USFS in cooperation with the AGFD completes the National Environmental Policy Act (NEPA) process for implementing a variety of recovery actions including approval of a major restoration effort on the Black River that could eventually support a major recreational fishery.

2003 – The Arizona Council of Trout Unlimited makes Apache Trout Recovery a top priority. The Council in conjunction with TU national develops a major funding and education campaign for Apache trout. The Council joins public and private partners to form the Apache Trout Recovery Partnership to implement restoration activities funded by new national grants.

Fisheries Management and Endangered Species Recovery

The issues surrounding sport fish management and endangered species can be controversial. Apache trout restoration highlights some of the potential conflicts, because AGFD, like many other fishery agencies, has a dual responsibility to conserve listed species as well as other non-game fishes and sport fish. As a first step in recognizing the importance of Apache trout as a native species, the White Mountain Apache Tribe closed all fishing for the trout in the 1950's in the Mt Baldy area. There wasn't any resistance from anglers at the time because the species had been reduced to less than 30 miles of stream habitat and it was clear that the action was warranted. Nevertheless, the WMAT also recognized the value of Apache trout as a recreational fish and pioneered the development of lake fisheries for large fish in the 1970's. Similarly, the USFWS, AGFD, and USFS were faced with balancing the needs for native species restoration with demands for recreational fishing opportunities. Early in their recovery efforts, these agencies recognized the value of Apache trout as a sport fish and used it to boost public support for endangered species recovery. This strategy was effective, but also has created additional challenges in communicating the differences between restoration and recreational objectives.

Unlike the issues generated by the impacts of introduced sport fish on endangered non-game species, Apache trout conservation involves the recovery of an endangered species that is an important sport fish. Like other native trout, the Apache's status as both a unique environmental resource and a recreational commodity should make the balancing of these issues easier to resolve. However, when other non-native trout species also become part of the restoration/recreation equation, communication of the issues to the sport fishing community and the larger public can become difficult and confusing.

Species Recovery Plans

Endangered species recovery plans must address the scientific and technical issues related to conserving a species and preventing its extinction. Typical recovery issues are population viability assessments, need for metapopulations, minimum population sizes suitable habitat criteria, extinction risks, and other complex assessments. Revision of the existing Apache Trout Recovery Plan began in 2000, and is still underway. Conceptually, the new plan should expand and improve the scientific basis of the 1983 recovery plan. Besides refining criteria that will be needed for ESA de-listing, the revised recovery plan could also improve on the 1983 plan by clarifying and addressing the balancing of native trout restoration with the introduced trout that support recreational fisheries.

Besides addressing ESA scientific and technical issues, recovery planning can provide a forum that improves public understanding of the broader issues. For Apache trout, the biggest opportunity to improve public understanding of the broader issues is to identify a long term vision of a recovered Apache trout species that expands the diversity of fishing opportunities in Arizona. Most anglers are well aware of Apache trout recreational potential through the lake fisheries that have been established over the years. Much of the remaining angler uncertainty involves recreational opportunities on recovery streams. This uncertainty could be alleviated by identification of Apache trout streams that would not only meet ESA delisting requirements, but also support robust recreational fisheries.

Restoration and Recreation

Apache trout recovery, like all native trout recovery, revolves not only around the question of how recovery is conducted, but also why certain actions are undertaken, and the long-term ramifications of those actions. Clear and concise rationale for conservation actions is essential in recovery planning. The Partnership has played a key role in implementing restoration projects, but it was not designed to be a forum for stakeholders to address complex and controversial issues. These kinds of policy issues can only be debated in policy forums such as the public comment periods on proposed government actions that is provided under National Environmental Policy Act (NEPA). A major test for the balancing of Apache trout restoration with recreational fishery interests occurred during a NEPA review that occurred from 2002-2004.

The basic approach to Apache trout recovery is similar to other native trout, and includes removing introduced trout species from recovery streams and replacing them with pure Apache trout. The streams that will receive this treatment occurred on Forest Service lands and were subject to a NEPA review. There was broad support for the Apache trout recovery proposal from the angling public during the NEPA process. Two factors were prominent in angler support during the NEPA process: 1) a portion of the angling public had detailed knowledge of the species recovery process through the Apache Trout Recovery Partnership; and, 2) many anglers had past positive fishing experiences with Apache trout. Although a few anglers expressed dismay over loss of fishing opportunities for non-native trout, most anglers understood both the species recovery reasons and the potential angling benefits of the proposed actions.

Balancing Native Fish Recovery and Recreational Fisheries

Unlike some other native trout recovery situations, the current Apache trout recovery program has not generated an unusual amount of conflict among recreational anglers. Although there was some minor dissent during the NEPA process, much of the support can be traced to the long history of Apache trout recovery and the active promotion and development of the species as a sport fish. Nevertheless, there still have been tradeoffs and compromises between native fish advocates and recreational fisherman. Recreational fishery stocking and protection of native fish, regulations for small stream fisheries, and conversion of non-native fisheries to native Apache trout are just some of the issues that will continue to be addressed.

In dealing with these issues, the underlying technical questions revolve around what is biologically necessary (and feasible) to recover native trout species, and recreational demand for the resource. Sound science and current information should always provide the framework for this decision-making, but our knowledge base is often incomplete. When this happens, science is combined with human value judgments and recovery efforts can be influenced by these societal values, and arguably, may result in differing objectives or conservation and recovery emphasis. The Partnership that was formed, and the associated grant that was awarded, allows the Partners to work towards a common goal with open communication of issues, identification of threats and associated conservation needs, acquisition of research or contract work necessary to accomplish the goals, and assistance in communicating with the angling public during the process. There is also little doubt that development of recreational fisheries for Apache trout has laid the necessary foundation for continued steps forward.

The progress in the Apache trout recovery program has proven that native fish recovery, the Endangered Species Act, and recreational fisheries have much in common. There is potential for advocates of different viewpoints to work in harmony because they ultimately have the same interests in healthy watersheds and fish populations. The good news for Apache trout and other native trout species is they are great sport fish and a valuable recreational resource.

Acknowledgements

We thank the following individuals that have played integral roles in Apache trout recovery and who were involved in many of the actions covered in this paper. We thank Larry Riley (AGFD), Scott Gurtin (AGFD), Mike Lopez (AGFD), Kelly Meyer (AGFD), Amy Unthank (USFS), Jerry Ward (USFS), Leslie Hartsell (USFWS), Stewart Jacks (USFWS), Tim Gatewood (WMAT), and Don Duff (TU). Of course there are numerous others that have played significant roles in this process, and we thank those that played direct or indirect roles in making this possible.

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Balancing the Management of Native and Introduced Species

Bob Jacklin

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Good afternoon!

Thank you for the opportunity to address such a prestigious group of fisheries professionals and for the privilege to participate in today's panel discussion on "Balancing the Management of Native and Introduced Species."

I am Bob Jacklin, outfitter and guide for the last thirty-five years in West Yellowstone, Montana. For forty years, I have made my living by selling fishing tackle. I am also a charter member of the Federation of Fly Fishers (FFF), President of the Western Rocky Mountain Council of the FFF, a long-time member of Trout Unlimited, of the Theodore Gordon Fly Fishers, and of the Anglers Club of New York City. Most of all, however, I'm a proponent of safeguarding our cold water fisheries and our national treasures like Yellowstone National Park and the surrounding waters such as the Madison River, the Henry's Fork of the Snake River, the Yellowstone River, and many others. My love for trout and trout fishing started long ago. As an eight- or ten-year-old, I was captivated by the romance and the tradition of trout fishing, when I saw firsthand the lure of "Opening Day of the Trout Season" in my home state of New Jersey. The fishermen were decked out in brown canvas or tweed jackets, in some cases with ties, including their lucky fishing hats, wicker creels, chest waders, and bamboo fly rods. They were nearly all well-dressed anglers. By the time I was seventeen, I was tying and supplying several tackle shops with custom flies for their dapper customers.

Today, I owe everything I have to trout and fly-fishing. For me, it is much more than money or self-aggrandizement. I love fly-fishing for trout; it is my first love and a confirmed way of life. As one who is entering his senior years—I will be 60 years young this January—I still have all the vigorous passion and love for the romance, the tradition, and the history connected with fly-fishing for trout, and I have the drive to leave our fisheries better than I found them.

This afternoon, therefore, I would like to present several comments and questions that I hope will stimulate some productive discussion, for I have spent many years observing fisheries and talking to fisheries people about resource management, as well as participating in stream and habitat improvement. My thoughts and comments are in keeping with today's program of balancing our native and introduced species. First, however, let me tell you that I have spent almost my entire life studying trout and trout fisheries. Although I have no formal education in the fisheries management field, I have studied much on my own. I'm self-taught, as it were. Furthermore, I am willing to learn and to keep an open mind.

Some years ago, the late Lee Wulff, one of my mentors in fly-fishing, for whom I have the greatest respect, presented a paper at Wild Trout Two, in 1979, which, by the way, I attended. As Lee observed then, finding a beautiful pool in a beautiful stream and have it devoid of fish is a fisherman's nightmare. Finding that same pool filled to its potential with hard-to-catch trout is a welcome challenge. Today, Lee's comment fits in with my main question for you: What are we managing for? Do we have a goal, a plan, and an objective for the fisheries in question? Have we formulated a fully articulated mission statement to guide us along that course? Is part of that plan designed to accommodate the recreational needs of the public? If so, great. If not, then why not? My question for you and your respective state, federal, or other agencies is, what is your goal? If you have a mission statement, are you making progress towards its goals? Are these goals realistic? Does the mission statement allow introduced species to have a place in our fisheries management? We must provide and use to their full advantage these introduced species. These trout, though non-indigenous, are what I term “naturalized natives” where they are self-sustaining and providing good recreational opportunities for the sport fishermen.

I thank God that, in my lifetime, I have seen and been privileged to participate in three different managements tools intended to provide sport fishing for the public. First, is Put-and-Take trout fishing, where we put the fish in and then take them out. This option does provide some good recreational value, but it should only be used where there are no other options. The second tool is the most useful and cost-effective means of managing our fisheries: Manage for All-natural Reproduction, using the indigenous trout for that purpose. I consider myself very lucky to have been shown a wild brook trout fishery in my home state of New Jersey, when I was just thirteen years old. That wild trout fishery in New Jersey , considered to be a heritage strain, still exists today, and it provided me with many years of valuable quality recreation and the chance to study and observe the movements of wild fish in their natural habitat. This second management tool should be used wherever we can as long as the fishery will sustain itself and provide recreational opportunities for mankind and subsistence value for our wildlife. The third management tool I have observed is what I label “Semi-Wild.” I have seen this tool used very effectively for many years in the state of Idaho—for example, on the Henry’s Fork of the Snake River and on other waters in this region. This management tool is nothing more then stocking fingerling size trout to supplement and to enhance populations where the natural reproduction is not strong enough to supply sufficient numbers of catchable-size trout. This supplementation of fingerling size fish allows a more natural answer to stocking by allowing the smaller fish to filter into the eco system in a more natural way with much less negative impact to the total fishery. This Semi-Wild management tool is obviously very cost effective compared to the Put-and-take option, and it provides a more natural approach to balancing the management of our native and introduced species and still provides the public with a quality angling experience.

The key words here are: 1) Balancing, 2) Keeping an open mind, 3) Using good common sense, 4) Having realistic goals with a well-thought-out mission statement, and 5) Avoiding the implementation of blanket policies that, in most cases, do not yield truly sought after or practical solutions.

I realize that my views may differ from those of the National Park Service or the U.S. Fish and Wildlife Service or those of your home state or agency. Like Lee Wulff, however, I devoutly believe that having that beautiful pool filled to, or balanced to, hold the maximum amount of catchable-size trout to temp the angler and to provide ample nourishment for our wildlife is a praiseworthy and attainable goal. We must do all we can to safeguard our headwater streams, the home range of native indigenous species, to reestablish and protect our native species wherever we can, to balance our fisheries, and to use these introduced species to their full advantage. In some cases, these introduced species have adapted quite well and should be treated like the “naturalized” gems they are.

Again! Thank you for the opportunity to present my views on balancing our fisheries.

God Bless!

Bob Jackl