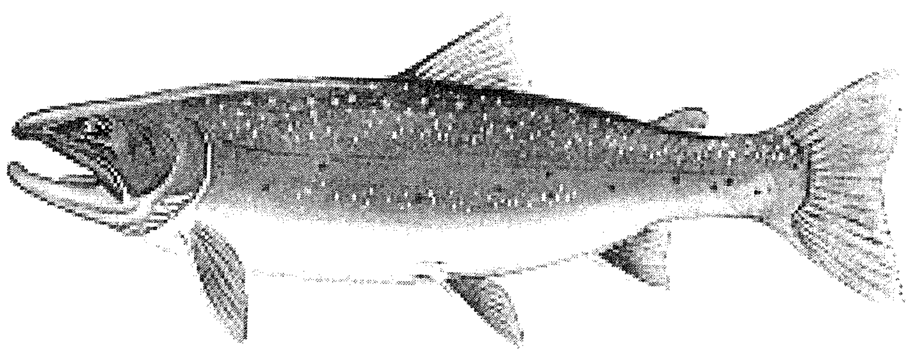
Assessment of methods for removal or suppression of introduced fish to aid in bull trout recovery



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EXECUTIVE SUMMARY

Introduced brook, brown and lake trout have contributed to the decline of bull trout *(Salvelinus confluentus)* in Montana. Removal or suppression of these introduced species may play a role in recovery of bull trout in some circumstances. This paper discusses the removal or suppression of introduced fish as one aspect of the recovery process for bull trout in Montana.

The protection of habitats supporting bull trout will be the most effective means of maintaining a competitive advantage for bull trout over introduced species. Habitat protection in core areas and nodal habitats should be a primary emphasis of any bull trout restoration program. While this does not assure the exclusion of introduced species, it is a logical first step in bull trout restoration. Before removal or suppression of introduced species should be undertaken, further introductions of these species should be discontinued.

Goals of the removal or suppression projects should be well developed and should include a determination of whether the effort will attempt to totally remove or just suppress the target species. A panel should be established to review all proposed suppression and removal projects.

A review of the use of toxicants, trapping and netting, electrofishing, and angling as removal agents indicates that they may help in site-specific situations such as small streams and lakes. But none, even in combination, will be practical on a large scale for bull trout recovery under most circumstances. Complete removal of introduced fishes will be possible in only a few site specific instances. Even if total removal of introduced species is achieved, it may not result in bull trout recovery.

Habitat manipulation to favor bull trout is probably not possible when introduced species are present and habitat restoration probably would aid in bull trout recovery.

Five situations are identified where removal and suppression should considered. They are not listed in order of priority:

1. Where recent invasions of introduced species have occurred or when the target species is restricted to a small area or is not well established but has a high potential for spreading.

2. Where it is necessary to protect core areas and nodal habitats.

3. Where a bull trout population is in immediate danger of extinction.

4. Where preservation of native species is a priority.

5. Where innovative experimental projects will further the knowledge of how this tool might be most effective. While all removal projects are experimental in nature, this refers to innovative projects that attempt to learn more about techniques and population effects of projects. New and innovative ideas and methods will have to be developed before introduced species control will be successful, particularly in large, complex lakes and streams.

The potential for negative impacts on non-target fauna is discussed and a checklist is included that should be reviewed before any suppression or removal project is undertaken.

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1

Introduction

In January, 1994, the Governor of Montana established a Bull Trout Restoration Team to develop a restoration plan for bull trout (*Salvelinus confluentus)* in Montana. The Restoration Team created a Scientific Group to provide guidance on technical issues related to the restoration of this fish.

The Scientific Group reviewed the status of bull trout and the risks to its survival in Montana. In addition, the Scientific Group recognized a need for technical reports on three of the most significant issues in bull trout restoration:1) Land use impacts, 2) the use of fish stocking and, 3) the suppression or removal of introduced species. This report discusses the role of suppression or removal of introduced species in bull trout recovery.

The protection of habitats supporting bull trout will be the most effective means of maintaining a competitive advantage over introduced species. Introduced species are found in some pristine habitats, however they often predominate in degraded habitats. Habitat protection in core areas and nodal habitats should be a primary emphasis of any bull trout restoration program. This principle is recognized in the status reviews as all core areas and nodal habitats are identified and their protection is fundamental to bull trout recovery.

Introduced species of fish are recognized as one of the most commonly cited factors for extinction or the imperiled status of native fishes in North America (Lassuy 1994, Miller et al 1989). Several species of introduced fish are believed to contribute to the decline of bull trout in Montana.

Removal or suppression of these introduced species may play a role in recovery of bull trout in some locations. This paper is not meant as a review of methods or "how to" specifically go about removing or suppressing a target species; there are many site specific considerations for each project and other sources are available for that information. Rather, it is meant as a general guideline to illustrate which methods have been successful and under what conditions removal or suppression should be used for bull trout recovery.

The removal or suppression of "undesirable" fish species has been used as a management tool for many years. Some of the results of efforts to remove and suppress introduced fish are available in published literature, but many projects are not well documented or are available only in reports that are not readily available. For this reason, several scientists with expertise in this area were consulted for this review. Their names and affiliations are listed in Appendix A.

Historically, toxicants and other methods were used to remove species that were perceived to be adversely interacting with more desirable sport fish. Often the target species were native suckers or minnows or other "nongame" fish. In some cases, even bull trout were targeted. Removal or suppression for the recovery of native fishes may mean the removal of introduced game fish species. Since, introduced species are often desirable gamefish, this can be a problem for bull trout recovery.

2

Considerations towards developing goals for removal/suppression programs

Before any effort is undertaken to remove or suppress a population of adversely interacting fish, it is important to identify factors responsible for the decline of bull trout. After the ecological and social considerations have been reviewed (see the checklist on page 19), a long term goal should be formulated and a commitment made to carry it out.

The effect that the introduced species is having on bull trout should be examined. Large removal projects have not always had a positive effect, because it was not clear that the target species was competing with the species that was supposed to benefit from its removal (Moyle et al 1983). Also, removal of adversely interacting species may be treating a symptom rather than the cause of bull trout decline, which may be habitat degradation (Platts and Rinne 1985, Maugham and Nelson 1980). Bull trout populations can be seriously impacted by land management practices. Often, however, introduced species are also likely adversely interacting with bull trout (Clancy 1993, Ratliff and Howell 1992, Washington Department of Wildlife 1992).

When removal or suppression efforts are anticipated, it would be reasonable to use a habitat ranking system to prioritize the streams on which to work. Streams with the highest quality bull trout habitat should have a high priority, because the bull trout populations should be more likely to respond positively (Jeffrey Dambacher, Oregon Dept. of Fish and Wildlife, unpublished data). If competition does exist where the habitat is suitable, removal of competing species can benefit native trout (Flick and Webster 1992, Moore et al 1983).

If introduced fish pose a risk to bull trout recovery, alternatives to reduce the risk should be reviewed. If there is both a significant risk to bull trout and a clearly identifiable action to reduce the risk, it is important to identify whether total removal or suppression is the goal.

Total removal implies that all of the adversely interacting species will eventually be removed and that some mechanism to preclude them from reintroduction should be identified. It would be beneficial to know the historic patterns of invasions by the introduced fish (Larson and Moore

1985). If a species encroached from another site through natural means, removal without excluding the invading species will probably be unsuccessful in the long term. If the target species was introduced into the target area by man, removal alone may be successful.

Suppression implies that a reduction in numbers of adversely interacting species will allow recovery of bull trout. This could be a short term project for experimental purposes as occurred in Great Smoky Mountains National Park (Moore et al 1983). It could also be a long term project but commitment of time and money for the long term is necessary. If species interactions alone are not the true cause of bull trout decline, then suppression alone will not work and the adversely interacting species will probably return to pre-suppression levels.

3

Potential for species conflict and reasons for control

The introduced species addressed in this paper are brook trout (*Salvelinus fontinalis*), lake trout *(Salvelinus namaycush)* and brown trout *(Salmo trutta)*. Conflict between introduced species and bull trout is often implied by the absence of bull trout in waters where they historically occurred or the existence of fish populations where introduced species predominate over bull trout. The precise mechanisms creating a survival advantage for the introduced species, leading to the replacement of bull trout, are not well understood. At the present time, a prudent approach would be to discontinue the stocking of introduced species in all core areas and nodal habitats of bull trout. Furthermore, stocking of brown, brook and lake trout and predatory species that have unknown impacts on bull trout should not occur within western Montana without an environmental assessment. Private ponds are growing in number and are a potential source for introducing exotic species into bull trout waters. The private pond problems will be difficult to control. Strong education efforts are needed to discourage the illegal introduction of exotic species into bull trout waters.

Brook trout

One of the difficult problems biologists face with regard to the conservation of bull trout is the widespread distribution of the introduced brook trout throughout the bull trout range. Hybridization between brook trout and bull trout has been reported in Montana (Leary et al 1983, Clancy 1993), Alberta (Scott and Crossman 1973), and Oregon (Markle 1992). The hybrids are usually sterile (Leary et al 1991).

The frequent production of sterile interspecific hybrids is an unstable situation that could lead to the loss of one of the two parental types. Life history differences between bull and brook trout tend to favor the brook trout in this situation (Leary et al 1991). Brook trout become sexually mature at age two or three, are relatively short-lived, and tend to "overpopulate" small streams. In contrast, bull trout do not reach sexual maturity until 3-6 years, and are long lived (Scott and Crossman 1973).

Reiman and McIntyre (1993) felt that migratory bull trout may have a reproductive advantage over brook trout because of their large size and corresponding higher fecundity.

However, resident bull trout would tend to have similar fecundities as brook trout. Leary et al (1991) present data from Montana which tends to confirm the hypothesis that brook trout can replace resident bull trout when interbreeding occurs. Bull trout have been largely replaced by brook trout in the South Fork of Lolo Creek where hybridization was first detected in the early 1980's. The authors expect this trend to continue until bull trout are extirpated from the stream or brook trout meet an upstream dispersal barrier.

Brook trout may be able to outcompete bull trout in some habitats, particularly those containing more sediment and higher temperatures. Brook trout tend to have higher survival-to-emergence than cutthroat trout and probably bull trout in high sediment habitats (Hausle and Coble 1976, Irving and Bjornn 1984, Weaver and Fraley 1991).

In the Bitterroot River drainage, Montana, brook trout and bull trout do not coexist in large numbers, indicating competitive mechanisms between them (Clancy 1991). On the Bitterroot Forest, bull trout are found only in small numbers in 20% of the high risk drainages. (High risk drainages are those with a high level of development). Brook trout are found in 85% of the high risk drainages. This distribution indicates that brook trout may be more competitive in drainages that are impacted by development (Clancy 1993).

Warmer water temperatures may give brook trout a competitive advantage over bull trout. In Sun Creek, Oregon, a bull trout population exists in a cool section of the stream while brook trout use warm areas upstream and downstream (Dave Buchanan, Oregon Department of Fish and Wildlife, personal communication). In a colder spring-fed stream in the Metolius basin of Oregon, bull trout are the dominant species downstream from the confluence and brook trout are dominant in the receiving stream above the confluence. (Mike Riehle, Deschutes National Forest, personal communication). In western Montana, brook trout are predominant in the warmer reaches of 3rd-5th order streams of the Bitterroot basin, but they are also found in reaches with some of the coldest midsummer water temperatures. Typically, bull trout are found in the colder reaches at higher elevations but considerable overlap of the two species occurs in reaches with colder midsummer temperatures (Chris Clancy, personal communication). Although there have been no studies of competition between bull rout and brook trout, brook trout are more competitive with cutthroat trout as water temperature increases (DeStaso and Rahel 1994), and as gradient decreases (Griffith 1972).

Although the data are not definitive, a healthy riparian area that provides shading to a stream and helps maintain lower midsummer water temperatures, will likely be a factor that helps bull trout resist competition from brook trout.

Brook trout probably contributed to the loss of bull trout from provincial parks in southern Canada (Dave Donald, Environment Canada, personal communication) and the decline of a bull trout population in the South Fork of Lolo Creek in Montana (Leary et al 1991). Brook trout are a serious threat to bull trout populations in Oregon (Ratliff and Howell 1992) and have replaced bull trout in South Fork Beaver Creek, Methow River basin, Washington (Ken Williams, Washington Dept. of Fish and Wildlife, personal communication).

Brown trout

We have very limited information on the interactions of brown trout and bull trout. Brown trout often use the lower reaches of streams in Montana while bull trout use the upper reaches. This is also common in other states (John Fortune, Oregon Dept. of Fish and Wildlife, personal communication). However, there may be overlap in use of spawning sites and juvenile rearing areas.

Brown trout spawn in the fall one or two months after bull trout spawn. They may use the same spawning sites, competing for spawning space, as both species use areas with similar substrate and ground water inflow (Pratt & Huston 1993). Competition for space could be keen between migratory bull trout and migratory brown trout as they would spawn in similar areas, with brown trout potentially digging up bull trout redds. Resident bull trout would use smaller substrates and potentially separate areas from the migratory brown trout.

Juvenile migratory bull trout and brown trout use similar types of habitats. Competition for rearing resources is likely. Brown trout would probably have the competitive advantage as brown trout appear more aggressive and territorial than native char (Wang and White 1994, Nilsson 1963). Brown trout can also replace brook trout (Waters 1983, Fausch and White 1981).

Considering the similar niche requirements of the two species, we suspect brown trout could negatively impact bull trout. After habitat changes caused by the McCloud Dam on the McCloud River, California, brown trout numbers increased and bull trout numbers decreased (Rode 1990). The author believes brown trout impacts on bull trout could have been substantial. Brown trout displaced bull trout where their ranges overlap in the Kananaskis River system, Alberta (Nelson 1965). Pratt and Huston (1993) note that brown trout and bull trout achieve similar sizes and spawn in similar locations in the lower Clark Fork River drainage, Montana, which may result in disruption of bull trout redds. In addition, both species use the same nursery areas, which may result in competition for resources. Bull trout declined and brown trout increased in Boulder Creek in the Sprague River basin, Oregon (Ziller 1992). Warmer water temperatures, favoring brown trout, may result from removal of forest canopy near the stream (Jeffrey Ziller, Oregon Dept. of Fish and Wildlife, personal communication). Colder midsummer water temperatures could favor bull trout over brown trout.

The consequences of suppressing adult brown trout are unknown. Brown trout recruitment can be suppressed when the population is dominated by mature fish (Oswald and Brammer 1993). Conversely, this implies that recruitment may increase if mature fish are suppressed. These phenomena occur in streams of southwestern Montana (Richard Oswald, Montana Dept. of Fish, Wildlife and Parks, personal communication). If compensatory increases in younger brown trout occur, the impact on bull trout could be negative.

Overall, we believe considering control of brown trout populations is a valid option.

Lake Trout

Lake trout typically use lake habitats throughout their lives but can use streams for spawning and dispersal corridors. Adfluvial bull trout are much more likely to interact with lake trout than resident or fluvial bull trout.

Typically we expect lake trout and bull trout spawning to be isolated in time and space. Lake trout spawn in the late fall and early winter, later in the season than bull trout and they usually spawn in lakes. Juvenile lake trout and juvenile migratory bull trout use different habitat areas until the juvenile bull trout move from their natal streams into lake habitats, where it is likely they use the same habitats as juvenile fish.

Lake trout negatively affect bull trout (D. Donald, personal communication, Donald and Alger 1993) and other char (Newell 1958, cited in Kircheis and Kornfield 1995). Donald and Alger (1993), in their study of 34 Rocky Mountain lakes in Montana, Alberta, and British Columbia, concluded that lake trout can limit the distribution and abundance of bull trout in mountain lakes. They stated that lacustrine populations of bull trout usually cannot be maintained if lake trout are introduced, although there are exceptions. Evidence that lake trout is the dominant species includes 1) displacement of indigenous bull trout populations by introduced lake trout, 2) unsuccessful "natural" colonization by bull trout of suitable low-elevation lakes that support lake trout, 3) and relatively high mortality of sympatric bull trout populations. Bull trout and lake trout had substantial overlap with respect to food utilization and growth, which suggests that competition may also contribute to the disjunct distribution of these species (Donald and Alger 1993). Although the mechanism is unknown, lake trout may aggressively exclude bull trout from foraging areas or otherwise compete for food or habitat resources (D. Donald, personal communication).

Marnell (1985) mentioned the introduction of lake trout as a possible factor contributing to the decline of bull trout in some areas of Glacier National Park. Lake trout numbers increased at the same time bull trout declined in Flathead Lake, Kintla Lake, Lake McDonald, and Whitefish Lake declined. It is suspected that the introduction of lake trout and/or brook trout played a role in the extirpation of bull trout from seven lakes in southern Canada (Donald 1994).

Montana Fish, Wildlife, and Parks (1992) suspects that lake trout predation on, and competition with, bull trout may be impacting bull trout populations in the upper Flathead River system. Although lake trout and bull trout have coexisted in Flathead Lake since the introduction of lake trout in 1905, there have been major changes in the food web of the lake since the introduction of mysis shrimp in the early 1980's. In the late 1980's, lake trout populations increased markedly in Flathead Lake. Juvenile lake trout began to appear in the river systems connected to Flathead Lake as far upstream as West Glacier on the Middle Fork of the Flathead and the Canadian border on the North Fork of the Flathead. Downstream of Flathead Lake, lake trout have been found in the Clark Fork and Jocko rivers. A 1991 survey of 23 lake trout stomachs from the Flathead River produced eight westslope cutthroat trout and one juvenile bull trout. The overall impact of lake trout competition and predation on bull trout abundance is not known but lake trout limits were increased in 1991 in an attempt to reduce predation, among other things (J.Vashro, personal communication, Montana Fish, Wildlife, and Parks, 1992).

A panel of experts recently convened to assess the possibilities for protecting the cutthroat trout in Yellowstone National Park from lake trout introduced into Yellowstone Lake. They concluded that lake trout will likely reduce the cutthroat population and a long term commitment to an aggressive lake trout control program could reduce, but not eliminate, the loss of cutthroat. In Yellowstone Lake, the lake trout and cutthroat trout are somewhat spatially isolated during much of the year and the cutthroat population is still large enough to withstand some incidental mortality.

It is known that fishing can change the age structure of lake trout populations by removing larger, older individuals (Luecke et al 1994, Evans and Willox 1991). But data from many lake trout populations indicate that mortality among older age classes can produce a compensatory increase in growth and survival among younger age classes due both to reduced intraspecific competition for food resources and reduced rates of cannibalism (Evans and Wilcox 1991, Martin and Olver 1980). Such an increase of younger lake trout could lead to even more competition with bull trout. Careful monitoring of any lake trout removal or suppression program will be needed to determine if this effect is occurring.

If the watershed restoration goals call for adfluvial bull trout, and lake trout are present, we believe that lake trout control would be desirable. A long-term project of the type planned for Yellowstone Lake could suppress some lake trout populations in western Montana. However, the degree of possible suppression and its influence on bull trout recovery is unknown.

Rainbow and Yellowstone cutthroat trout

Rainbow trout *(Oncorhynchus mykiss)* and Yellowstone cutthroat trout *(Oncorhynchus clarki bouvieri)* have been widely introduced into bull trout ranges. Since bull trout live sympatrically with native rainbow trout in portions of its range and with one subspecies or another of cutthroat trout, we suspect their presence may have less impact than brook, lake and brown trout. However, there is limited data. Bull trout and coastal cutthroat coexist by using slightly different feeding behaviors and habitats (Schutz and Northcote 1972). This document will not discuss rainbow trout and Yellowstone cutthroat trout further because we believe there is little evidence to implicate them in the decline of bull trout.

Other species

Other species of fish are probably competitors with bull trout but these interactions have not been well documented. Data collected in 1995 in the Clearwater Chain of Lakes in the Blackfoot River drainage, Montana, indicate that illegally introduced northern pike, *(Esox lucius)* are preying heavily on native bull and westslope cutthroat trout (Rod Berg, personal communication). When situations like this are identified, the removal or suppression of the competitor species should be considered.

4

Direct methods for removal and suppression of introduced species

Toxicants

Removal of undesirable fish from lakes and streams in the United States began early in the century and has accelerated in the past 40 years as toxicants and technology improved (Marking 1992). Toxicants can be very effective in capturing and removing fish (Krumholz 1948). This makes them useful in many situations but it also increases the likelihood of misapplication. Typically, in closed lakes, the toxicant naturally dissipates but, in streams, it is necessary to use neutralization methods. Even with neutralization, the possibility of a downstream fish kill exists.

Toxicants that selectively kill a target species without harming non-target species are the most desirable. Baits impregnated with toxicant have been used to kill specific species (Rach et al 1994). No selective toxicant is available to use against fish species that are known to compete with bull trout. In the West, the most commonly used toxicants for removing fish are rotenone and antimycin. Both toxicants are appropriate for lakes. Antimycin is effective in streams since fish do not avoid it like they do rotenone (Dan Carty, U.S. Fish and Wildlife Service, Yellowstone National Park, personal communication). Antimycin is highly effective in cold water temperatures with a neutral pH and neutralizes with agitation in stream environments. It is less toxic in alkaline waters. However, the Environmental Protection Agency certification for antimycin will expire within two years and it may not be produced after 1998. Rotenone is effective at all pH's, but is not easily neutralized, especially at temperatures less than 50° F.

Lakes

Historically, total removal has been accomplished in many lakes (Flick 1992, Foye 1964, Ball 1945). Removal is more difficult in larger and more complex lakes with springs and inlet and outlet streams (Foye 1964). Selective poisoning of some species is possible (Greenbank

1940), and in large, complex lakes, suppression of certain species, rather than total removal is often the goal. Typically, the suppression effort must be repeated every few years because the adversely interacting species usually return to pre-suppression levels.

Rivers and Streams

Using toxicants to remove adversely interacting species in smaller lakes may be feasible for bull trout recovery. The same principles apply to streams. The larger and more complex the stream system, the more likely the goal will be suppression instead of removal.

Toxicants have been used for native trout restoration projects in small headwater streams (Rinne and Turner 1991, Rinne et al 1981). Usually, a barrier is identified or built, the stream above the barrier is renovated and the native fish are reintroduced afterwards (Pittenger et al 1993, Propst et al 1992, Stefferud et al 1992). Successful removal of introduced species to benefit native trout species in this situation has been variable. In Yellowstone National Park, an introduced population of brook trout was successfully removed from Arnica Creek, a stream network composed of 44 km of channel (Gresswell 1991). The results of an experimental project to assess the effects of the removal of brook trout from portions of a stream containing bull trout in Oregon are not yet conclusive (Bruce Rosenlund, U.S. Fish and Wildlife Service, Fort Collins, CO, personal communication). Examples of projects that were not successful at total removal of the target species are numerous (Rinne and Turner 1991). Brook trout removal from streams is likely further complicated by their affinity to groundwater upwelling that may act as a refuge from toxins. Typically, toxicants should be used two years in a row on a reach of stream to insure success.

As the stream increases in size, both physical and social problems increase. Projects on large river systems are complex (Art Whitney and Bill Hill, Montana Department of Fish, Wildlife and Parks, personal communication, Moyle et al 1983, Binns 1967). Commonly, even in complex systems, a species that is particularly sensitive to the toxicant may be totally removed. In the case of non-target species, this outcome may not be positive. In at least one case, a renovation project may have destroyed native fishes previously unknown to science (Rinne and Turner 1991). The differential susceptibility of species within a community of toxins complicates removal efforts. The ideal case would be that the target species is susceptible to lower concentrations of toxin than native species, but this is seldom the case. Large rivers are highly accessible to nearly all fish species inhabiting a drainage basin and any target fishes that are only locally removed or suppressed are likely to reinvade.

Past attempts at removing fish species from large rivers have been controversial (Holden 1991, Hubbs 1963). Public acceptance of fish removal or suppression projects is not likely to occur in the large rivers and streams which support considerable recreation and other uses, particularly because introduced species in large rivers are typically popular sport fish. The likelihood of a successful renovation project is poor in large streams so efforts should focus elsewhere.

Conclusion

Based on the collective experience of the Montana Bull Trout Scientific Group, a review of pertinent literature and discussions with other scientists, we expect the removal of introduced species using toxins will be a useful but limited tool in bull trout recovery. Due to the tenacious nature of introduced species to avoid elimination and the time consuming and costly nature of removal projects, we see this as a useful tool in only a few small streams and lakes.

Trapping and netting

Lakes

In lakes, seasonal trapping or netting may be used to remove introduced species. Generally, lake trout is the species of fish likely to impact bull trout in lakes, although northern pike and possibly other piscivorous species may also be a problem. If the spawning locations in a lake are limited, a trapping effort aimed at capturing and removing large spawners may be successful in reducing lake trout numbers (Jerry McClean, U.S. Fish and Wildlife Service, Lake Huron, personal communication). Also, during the spring, trapping in the shallows may be successful in reducing lake trout. Use of gill nets to selectively harvest lake trout if they occur at a different stratum in the lake than bull trout may be useful. Gillnets could be set for long periods of time with the sole purpose of capturing lake trout. A commercial operation would most likely be necessary to provide the necessary amount of effort to seriously deplete a large lake trout population.

The possibility of incidental catch of bull trout is a complicating factor in any large-scale trapping and netting effort because the loss of a few bull trout could have a serious impact on the population. This would have to be assessed on a site specific basis.

These methods will not remove all lake trout. A long-term project could suppress the lake trout populations but the degree of possible suppression and its influence on bull trout recovery is unknown. Public acceptance of a large scale lake trout removal project on large lakes which support considerable recreation could be difficult to obtain. The complicated interactions within a lake between many species of fish make any predictions tenuous. Without suppression, the adfluvial lake trout population could reach an equilibrium before the bull trout population disappears. However, past history of smaller lakes in Alberta indicates this may not happen (Donald and Alger 1993).

Rivers and streams

In some situations, trapping in a spawning tributary that is used by an adversely interacting species may be worthwhile. This method should be assessed on a site-specific basis.

Conclusion

Trapping and netting of target species is more likely to be used in lakes than in streams. It would not result in total removal. Trapping would most likely be used as a suppression measure to identify it effectiveness. It may be more acceptable to some of the public than using toxins but would still be controversial if the target species is a desirable gamefish. In very specific circumstances, when spawning of the target species is limited to one or few tributaries, trapping of spawning adults could lead to total removal.

Angling (sport)

Fishing regulations often favor the taking of one species over another and angling has been used to reduce densities of introduced rainbow trout (Larson et al 1986). One disadvantage of sport angling for removal or suppression is that anglers typically target larger size classes of fish, potentially resulting in an increase in the numbers of smaller fish, as was previously discussed for brown trout and lake trout. The result may be increased competition between introduced species and bull trout.

The loss of bull trout through incidental take would be a negative factor if angling were used to remove other species. The methods that capture brown trout and lake trout might also catch bull trout and some incidental mortality of bull trout would occur. Angler misidentification of fish species is a problem and a serious educational effort would be necessary.

Brook trout

In Montana, the creel limit for brook trout has historically been higher than for other trout (presently it is 20 brook trout per day in western Montana) so it is unlikely that raising the limit will significantly reduce brook trout numbers. Also, brook trout are prolific spawners that often live in streams that are brushy and difficult to fish. They typically do not grow large enough to interest most anglers so it is unlikely that a program to remove them by angling would benefit bull trout. Habitat change may be the overriding reason that brook trout dominate bull trout in some waters. If these habitat problems exist, they must be corrected before any fish removal project will be successful as a bull trout restoration tool.

Lake trout

Sportfishing aimed at removing lake trout would likely not remove enough fish to benefit bull trout without further incentives to anglers. In large lakes, many anglers favor sport angling for lake trout. It would be unrealistic to expect a massive fishing effort by the public to remove or seriously depress lake trout if anglers are unwilling to harvest large numbers of these fish. Most lake trout caught in Flathead Lake are kept but a substantial proportion are released (Evarts et al 1994). Even if a voluntary angler removal effort suppressed lake trout numbers, it is not expected that it would be of large enough proportion to benefit bull trout in Flathead Lake.

Incidental catch of bull trout is a concern with this strategy for lake trout removal, although some styles of angling in some waters can be selective for lake trout. For example, experience has shown that deepwater trolling (> 100 ft.) in Flathead Lake is selective toward lake trout and bull trout are seldom caught (Larry Lockard, U.S. Fish and Wildlife Service, personal communication). Other fishing techniques may result in high catch rates for bull trout. Educating anglers about proper fish identification should be a high priority in mixed species fisheries when minimizing the incidental take of bull trout is desired.

A bounty on lake trout may be a useful incentive in removing a significant portion of the population. The consequences of this action could be similar to that discussed under trapping. If a bounty was used, an educational effort would be needed to teach anglers how to distinguish bull trout from lake trout.

Brown trout

Brown trout may compete with bull trout. Angling to remove brown trout from bull trout waters would likely be ineffective. Brown trout are more difficult to catch than many other trout, are popular with the public, and comprise the bulk of some of the larger river sport fisheries. Targeting brown trout for removal by angling would be unpopular with some anglers. Fishing regulations designed to remove brown trout could lead to depressed numbers of adults which could have unintended results (see Chap.3 - pg. 6).

Other species

Other species likely adversely interact with bull trout, but we have little relevant information about them. Northern pike predation may have serious impacts in the Clearwater Chain of Lakes. A liberalized bag limit on northern pike is not expected to be an effective means of controlling their numbers.

Conclusion

It is possible that a situation exists where angling for an adversely interacting species would benefit bull trout, particularly in combination with other suppression techniques, but the use of angling to remove adversely interacting species is not expected to be a major factor in the recovery of bull trout.

Angling (commercial)

Many biologists believe that, in the past, commercial harvest was one major factor that depleted some of the Great Lakes' lake trout fisheries (Myrl Keller, Great Lakes Fishery Station and Jim Selgeby, National Biological Survey, Lake Superior, personal communication). But the confounding effects of habitat deterioration, lake eutrophication, sea lamprey invasion and accumulation of toxins (Ryder et al 1981) have precluded a definitive determination of the effects of fishing.

While the intent of commercial fishing probably was not to deplete the lake trout populations, the methods used may be useful to help suppress lake trout populations in Montana.

Electrofishing

Electrofishing to remove an adversely interacting species has been undertaken in many instances. While electrofishing will typically lead to the capture of a high number of target fish, it is not a highly successful method for complete removal. Electrofishing is a useful tool for long-term suppression of introduced stream fish or to determine the effects of suppression.

One potential drawback of electrofishing, which is common to most removal techniques, is the impact it may have on non-target organisms. Electrofishing typically causes injury to some trout. The amount and degree of injury depend on many factors, including the species and size of fish, electrical waveform, electrode design, experience of the crew, and other factors. Mortality caused by the less injurious waveforms is typically low but physical and physiological problems can occur (Hollander and Carline 1994, Mesa and Schreck 1989, Barrett and Crossman 1988, Sharber and Carothers 1988, Sharber and Hudy 1986, Gatz et al 1986, Hudy 1985). Electrofishing can kill eggs in the gravel (Dwyer et al 1993). It is important to know the impact the particular waveform has on non-target species. Electrofishing does affect amphibians but the degree of impact is unknown (Chris Clancy, Montana Dept. of Fish, Wildlife and Parks, personal communication).

Electrofishing was used to completely remove rainbow trout from small streams in Great Smoky Mountains National Park (West et al. 1990) but it took a great deal of effort, including establishment of downstream barriers. It worked on very small streams that did not have complex habitats and was unsuccessful on larger streams (Habera et al 1992). The suppression effort did show that native brook trout populations would increase after removal of some introduced rainbow trout (Moore et al 1983). National Park Service biologists in Great Smoky Mountain National Park would prefer to use toxicants in the future because of the high amounts of labor involved with electrofishing (Steve Moore, Great Smoky Mountains National Park, personal communication). Biologists who have used electrofishing removal or suppression indicate that it is not a preferred technique in that situation.

In Crater Lake National Park, a brook trout removal project in Sun Creek appears to have been partially successful. The brook trout were removed in 1992, using antimycin and electrofishing, and electrofishing only in 1993 and 1994 (Mark Buktenica, Crater Lake National Park, personal communication).

Conclusion

Electrofishing is an effective technique for capturing large numbers of fish in many situations. It could be used to help suppress target species but would not be effective at total removal. Some situations may occur when removal by electrofishing could help bull trout gain a short term advantage over introduced species but this would usually be after habitat alteration or some other factor had occurred that could conceivably lead to a long-term advantage for bull trout. While electrofishing is effective at capturing large proportions of the fish populations in many situations, it has the potential to damage individual bull trout if not properly used. Overall, electrofishing to remove target species will be too costly and time consuming to be a major factor in bull trout recovery.

Barriers

Throughout the western United States, native trout recovery projects have typically focused on small, headwater populations. In most cases, an upstream barrier is either naturally present or constructed and the introduced species is removed upstream of the barrier by using toxicants.

However, total removal of an introduced species in isolated, headwater portions of a stream may not lead to recovery of the native population. In the case of bull trout, distribution and genetic evidence indicates that the resident populations in headwater streams were once connected to mainstem rivers and genetic interchange between them was accomplished by migratory fish. Isolated bull trout populations may be at risk from natural events that could lead to their extinction (Rieman and McIntyre 1993). For example, a headwater population of Gila trout was lost in New Mexico following a severe fire and flooding (Paul Turner, New Mexico State University, personal communication). Also, the construction of barriers to preclude adversely interacting species from recolonizing the renovated portion of a stream may be in conflict with true recovery of bull trout populations. These barriers may also preclude the immigration of migratory bull trout which may be important to the long-term survival of the population.

However, if removal of an adversely interacting species is the only way to insure the survival of a population of bull trout, a long term program of temporary barrier construction and removal of the target species may be successful. In Rocky Mountain National Park, a series of natural barriers on some streams allows for progressive downstream removal of cutthroat trout competitors (Bruce Rosenlund, U.S. Fish and Wildlife Service, Golden, CO, personal communication). Another option would be to design selective passage facilities that would allow migratory bull trout to pass through but would exclude introduced species.

Although barrier construction presents long term problems, in some circumstances they could be used to preclude the movement of an introduced species into a critical bull trout refuge. Most likely, this barrier would be designed to stop upstream movement of the introduced species (see the Swan Bull Trout Status Review). This type of structure could be a long term solution if the area upstream of the barrier contains all of the habitat components (core areas and nodal habitats) that are necessary for the long term survival of the bull trout population. A barrier would be most useful where upstream genetic interchange by bull trout did not exist or, could be provided with the barrier in place.

In some cases the reestablishment of a migratory component may not be possible and the use of permanent barriers would be appropriate. In these cases, true recovery is not possible, and the effort will be to protect the remaining resident populations.

5

Indirect methods

For the purposes of this discussion, we will use the following definitions:

Habitat protection - Maintenance of high quality habitat where it currently exists.

Habitat restoration - Restoring natural processes that bring the habitat back to its potential (e.g., restoring watershed function by addressing temperature, water and sediment yields).

Habitat manipulation - Physically altering a lake or stream to favor bull trout over an adversely interacting species (e.g., creating more pools or spawning habitat in a reach of stream to favor bull trout over brook trout).

Habitat protection

Watersheds presently supporting bull trout have the components that allow bull trout to successfully compete with introduced species. The protection of habitats supporting bull trout will be the most effective means of maintaining a competitive advantage over introduced species. Habitat protection in core and nodal habitats should be a primary emphasis.

Habitat restoration

Fish habitat should be managed on a watershed basis (Rinne 1988). Treatment of a small section of stream may not effectively address a widespread problem (Binns and Remmick 1994).

In a general sense, we have the tools to restore some stream habitats to a condition resembling their historic state. For example, we can increase the amount of woody debris to a historic level or control new sediment input from human-caused sources.

While this approach is likely to benefit bull trout, it is unclear whether it will give bull trout a competitive advantage over introduced species. Hopefully, bull trout in a restored drainage would be better able to compete with introduced species. However, practical examples of this type of work have not been documented.

Habitat manipulation

Habitat requirements of bull trout have been generally categorized. The bull trout and its close relative, the Dolly Varden *(Salvelinus malma)*, prefer large amounts of woody debris (Cardinal 1980, Dolloff 1986, Elliot 1986, Jakober 1995), cool water temperatures and upwelling areas (Goetz 1989) and a minimal amount of fine sediments (Clancy 1991, Weaver and Fraley 1991, Leathe and Enk 1985, Jeffrey Dambacher, unpublished data).

Over the years, many habitat manipulation projects have been completed, with varying amounts of success (Reeves et al 1991). Typically, they are aimed at increasing some perceived limiting habitat, such as pools, spawning areas, rearing areas, etc. Many projects have resulted in increases in size and number of both native and introduced species. Although we can identify some of the habitat preferences of bull trout, they are often similar or overlap the preferences of other salmonids. The art of habitat manipulation to improve bull trout conditions, at the expense of brook trout or other introduced competitors is not well established.

In streams with native species but no introduced species and poor habitat (e.g., high water temperatures, embedded substrates, little streambank or instream cover or marginal streamflows), habitat manipulation to improve these conditions could improve bull trout populations. However, in a stream where bull trout are competing with introduced species, these improvements may not benefit bull trout. A review of stream improvement projects in Wyoming indicates that there is not enough information to target a particular trout species (Allen Binns, Wyoming Game and Fish Dept., personal communication). The improvements may increase the competitive advantage of one species over the other but it would be difficult to predict. If habitat manipulation is to be used in this manner, monitoring of experimental projects is necessary.

Habitat manipulation in a reach of stream supporting only bull trout and other native species could increase downstream drift of bull trout if the bull trout population increases. This could be beneficial to the downstream bull trout population that may be adversely interacting with an introduced species (A. Binns, personal communication).

Another option that may have application in some limited cases is radically altering the habitat for a short period of time to favor bull trout. One tool might be the dewatering of a stream or reservoir to remove an adversely interacting species. This has been done to benefit other sport fishes. It is often done in combination with toxicants. Another method may be to temporarily remove beaver dams to increase the potential success of removing brook trout, then restocking with native bull and cutthroat trout. This option also requires a plan for preserving the remaining bull trout population during the project. Reintroduction of bull trout from the original population would most likely be necessary to maintain the genetic structure.

Conclusion

Maintenance of high quality habitat is the first priority in bull trout recovery. Habitat restoration on a watershed scale should help with bull trout recovery and instream habitat manipulation on a small scale is of limited value particularly if introduced species are present. Removal or suppression of introduced species in conjunction with habitat restoration or manipulation should be attempted.

Introduction of a biological agent

This technique involves introducing a biological agent to suppress or remove the adversely interacting species. The Bull Trout Scientific Group felt that this option is not appropriate at this time because there is not sufficient information on this subject and the risks of introducing another species of fish or other biological control agent are too high.

6

Recommendations

The protection of habitats supporting bull trout will be the most effective means of maintaining a competitive advantage over introduced species. Habitat protection in core areas and nodal habitats should be a primary emphasis of any bull trout restoration program.

Many of the historically used methods of removal or suppression would be useful to some limited extent. A combination of these methods may be most effective. However, at the present time, while we recognize the considerable impact that introduced species are having on bull trout, removal or suppression is not feasible on a large scale. It is clear from reviewing the literature and discussing this subject with many professionals that new, innovative means for removal or suppression are necessary if this method is to become a major factor in bull trout recovery. A recent review of fish control projects found that less than 50% of 250 projects were considered successful (Meronek et al.1996). The criteria for success used in this study were much less stringent than would be necessary for bull trout recovery. The use of removal or suppression in the traditional sense will only be a small part of bull trout recovery. Projects that proceed should be monitored closely so that more can be learned about various tools to deal with the problem of introduced species. The Scientific Group recommends a panel be established to review all removal and suppression proposals. This panel would serve as advisers to others that are contemplating projects.

Before removal or suppression of established introduced fish populations is undertaken, we recommend discontinuing the introduction of species that may adversely affect bull trout. The most common means of nonnative species introduction into bull trout range are State and Federal stocking programs, introduction through private pond permits and illegal introductions. Each of these must be carefully controlled if we expect long term success in removing or suppressing introduced species within the recovery area. Any introductions should be scrutinized through the proper environmental review process. If there is any reason to suspect that the introduction could directly or indirectly impact a bull trout population, it should not take place.

Presently, the stocking policy of Montana Fish, Wildlife and Parks discourages any stocking in streams that support wild or native trout. This reduces impact on bull trout populations. The most common introductions are westslope cutthroat trout *(Oncorhynchus clarki lewisi)* which are typically introduced into mountain lakes. However, within western Montana, some stocking of introduced species does occur.The stocking of exotic species except kokanee, rainbow trout and hatchery westslope cutthroat trout should be scrutinized through the MEPA process at all sites, including those where both a historic and current record of stocking exists.

Within core areas and nodal habitats all introductions should be scrutinized through the MEPA process.

Private pond permits are numerous and new applications continue to increase. We recommend a review of past permits and, if negative interactions are likely, consider revoking or modifying the permits. Any new permits should consider potential conflicts with bull trout.

Illegal introduction of fish by the public is a serious and growing problem. While this is a difficult problem to address, every possible means should be taken to stop the illegal introduction of fish into bull trout waters.

Priority situations for removal or suppression

Although the Scientific Group concludes that removal and suppression of introduced species will only play a minor role in bull trout recovery, we have identified five situations where they should be used. These five situations are not listed in any priority:

1. Where a recent invasion has occurred or a localized population of introduced species exists. If the invader has a high potential of spreading, it would be a high priority. This is the type of situation when a total removal program will be most successful.

2. In areas where core areas and nodal habitats must be protected

3. In critical, site-specific situations where a unique bull trout population is immediately threatened with extinction. It is important to determine whether the effort is a lost cause or has some possibility of success.

4. Where preservation of native species is among the highest fisheries priority (e.g., national parks, tribal lands, federal lands, wilderness areas).

5. Since more knowledge is necessary concerning the removal or suppression of introduced species, innovative experimental projects will be a priority toward understanding how this tool might best be used. While all removal projects are experimental in nature, this refers to innovative projects that attempt to identify new techniques that give bull trout competitive advantage over introduced species.

7

Non-target species considerations

When suppression or removal of introduced fish species is contemplated, consideration should be given to the effects of the project on non-target species (Wiley and Wydoski 1993). There will commonly be a risk of loss of unknown species, particularly when toxicants are used. This should be kept in mind during planning of the project. Some considerations concerning non-target species are:

1. A list of species present in the area could be obtained from the Montana Natural Heritage Program.

2. When using toxicants, assume all gill-breathing aquatic species will be eliminated from the treated reach. If a rare species is present, some means of protecting that species should be taken.

3. Populations of native fish, amphibians, plants and other sensitive taxa should be protected.

4. Some taxa of invertebrates will not be found using normal sampling procedures. Typically, invertebrate biomass recovers in a short period of time after toxicants are used. However, species that are present in small numbers are difficult to account for before and after the project (Minckley and Mihalick 1981). The effect of the project on rare taxa would likely be poorly understood. Also the effect on taxa that inhabit sites that are not sampled by ordinary methods would be unknown.

5. In situations where "unusual" habitat exists that may support a species with restricted distribution, some means of protecting these species should be taken.

8

Checklist for removal or suppression

The following questions should be answered before any suppression or removal program is initiated:

I. **Assess the need for removal or suppression of introduced species:**

A. Is there another alternative that may also protect bull trout?

II. **Clarify goals and measures for success:**

A. What life history form of bull trout will benefit?

B. What is the expected response of bull trout? Is the habitat available to support the expected response?

C. What is the spatial scale being considered? Is this project site-specific or does it relate to a larger area?

D. Is this a suppression or removal effort? If it is suppression, what are the long term commitments?

E. What will be the measure of success or failure?

III. **Evaluate how the removal or suppression fits into the recovery program:**

A. How does this project fit into the genetic plan for the drainage?

B. Is a recovery plan in place? How does this project factor into that plan?

IV. **Planning the effort:**

A. Have possible problems been anticipated? Have contingencies for accidents been explored?

B. Are there resources available for long term implementation and monitoring?

C. What is the potential for reinvasion or compensatory population response by the target species and how will this be addressed?

D. What non-target fauna exist and what are the expected impacts to them? (see Chapter 8).

E. How will fish disposal be handled?

F. What might be the public response/support/opposition?

G. What kind of NEPA (National Environmental Protection Act) or MEPA (Montana Environmental Protection Act) document is necessary?

H. Is there potential for offsite mortality? How will it be taken care of?

I. Is the body of water a source for domestic or livestock uses? Have all adjacent landowners been contacted?

J. Have all necessary permits been obtained (Water Quality, U.S. Forest Service, etc.)?

9

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Appendix A

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Appendix B

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