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THE ROLE OF HATCHERIES AND FISH TRANSPLANTS IN BULL TROUT RECOVERY

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prepared for:

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EXECUTIVE SUMMARY

This issue paper addresses the role of hatcheries and/or fish transplants in Montana's bull trout recovery effort. The issue of hatchery use in fisheries management, including native species recovery, is currently under debate. In consideration of this ongoing controversy, we believe it is important to discuss the distinction between traditional fish stocking and the hatchery uses proposed here. Introductory and background information is presented to define key terms and familiarize the reader with the breadth and scope of the subject matter. Historical information on bull trout culture, the ESA perspective, and the changing role of hatcheries are reviewed.

The Montana Bull Trout Scientific Group developed and evaluated potential strategies involving the use of hatcheries or transplants in bull trout recovery in Montana. These strategies collectively cover most possible scenarios we could foresee. Each strategy was screened using criteria and objectives developed by the Scientific Group (APPENDIX A). We discuss all strategies in detail with clear definitions as to what they entail and where they might be applied.

One scenario involved bull trout restoration without the use of hatcheries or fish transplanting. The Scientific Group unanimously rejected this strategy. We approved a strategy using hatcheries or transplants to provide genetic reserves for seriously declining populations. Restoration stocking was approved as a recovery strategy **only if** the actual cause of decline is identified and corrected first. We conditionally approved research strategies. These do not meet the criteria for restoration, but information gained through experiments may benefit restoration efforts. The Scientific Group rejected strategies using supplementation; new introductions; and put, grow and take as recovery efforts.

Recommended strategies focus on protecting unique stocks and restoration stocking, with the primary objective of establishing viable, self-sustaining bull trout populations. We recognize that these measures will not substitute for correction of the factors causing or contributing to present declines. Secondarily, we identified areas of research that might be useful in the recovery process.

It is our opinion that the approved uses of hatcheries and/or transplants are tools available for bull trout restoration efforts in Montana. While we differ somewhat in our individual opinions on implementation, we all agree that any projects involving these tools must be appropriate in scope, judiciously applied, rigorously designed and thoroughly monitored. To ensure that this occurs, we recommend a review panel be appointed by the Restoration Team to screen all projects involving the use of hatchery bull trout or transplants. Ultimately, our singular goal is full recovery of naturally-reproducing, wild bull trout populations.

INTRODUCTION

This issue paper was prepared to specifically address the use of hatcheries and transplants as tools in the recovery of bull trout (*Salvelinus confluentus*) in the State of Montana. The use of hatcheries in fisheries management, including native species recovery, is currently under debate. Our literature search turned up little published information that would be pertinent to the situation with bull trout in Montana.

Currently, in Montana, bull trout inhabit a reduced portion of their historic range and population trends are in decline in many of the remaining areas (see status reports). In broad terms, the restoration goal is to reverse this trend and protect self-sustaining populations of bull trout. In order to perpetuate "self-sustaining" populations, the causes of population declines must be addressed. The Scientific Group recognizes that stocking fish rarely addresses these causes. Therefore, the strategies outlined in this paper will be most useful in re-establishing populations after remedies are applied. Secondarily, the Scientific Group has identified areas where research with hatcheries and transplants may benefit recovery efforts.

The Scientific Group also subscribes to the overall approach of giving priority to those systems which are relatively intact. That is, with limited resources, use the appropriate techniques to protect and restore those systems that have the best chance of meeting goals, recognizing some systems are beyond repair and effort would likely be wasted attempting to recover bull trout. The use of any recovery tool should be weighed against the overall recovery effort.

The intent of this paper is to review the historical use of hatcheries and transplants as a recovery tool for other species, discuss the applicability of ongoing research to bull trout issues, and outline the Scientific Group consensus on what role hatcheries and transplants could play in recovering bull trout in western Montana.

Historical Review of Bull Trout Hatchery Programs

Bull trout are the most geographically widespread salmonid native to North America that has not been extensively cultured in hatcheries. In Montana, bull trout were reared in hatcheries in the 1940's and 1950's. In 1944, Montana Fish, Wildlife & Parks (MFWP) collected bull trout eggs in the Bull River (Clark Fork drainage). They planted the progeny in the Thompson River and Kootenai River drainages in 1945 (Pratt and Huston 1993).

In 1949 and 1950, MFWP collected over 876,000 bull trout eggs from the Clark Fork River drainage (Bull River, Vermillion River and Prospect Creek). These eggs and fish served a variety of uses. During 1950-1952, about 10,000 of the resulting fish were planted into Lake Pend Oreille (Pratt and Huston 1993) and about 65,000 into Flathead Lake, tributaries to the North Fork Flathead River, and the Stillwater River (USFWS 1993a).

In Canada's Kootenay Trout Hatchery near Wardner, B.C., personnel conducted experimental work with bull trout culture in the early 1980's. That program was transferred to the Hill Creek Hatchery near Upper Arrow Lake in the headwaters of the Columbia River drainage. It is part of a mitigation program for the construction of dams which cut off major bull trout spawning grounds for fish from Upper Arrow Lake. The goal is to replace 1,000 adult bull trout in the population by stocking 100,000 fingerlings. Wild fish are captured annually from several tributaries to Upper Arrow Lake, held in a penned off area of Hill Creek and spawned. Adults are returned to the lake and juveniles are scatter-planted in the tributaries as 4-inch fingerlings in September. Post-stocking evaluation of the program has been inadequate to assess its outcome. The program is continuing.

In 1989-1991, Idaho Fish and Game conducted a small experimental hatchery program at Cabinet Gorge Hatchery (Pratt and Huston 1993). Little information was obtained about this program. In 1993, an experimental bull trout culture project began at Creston National Fish Hatchery using eggs collected from the Swan River drainage. Experiments are underway to evaluate the effects of water temperature, diet, structure, cover, and rearing density on growth and behavior and to evaluate time of imprinting by juvenile bull trout via thyroid hormone analysis (Fredenberg et al. 1995). This summarizes known bull trout culture activities that have occurred in the Upper Columbia River Basin.

DEFINITIONS

Because of the large and diverse body of literature and the variety of definitions that have been published, the Scientific Group felt it was necessary to prepare concise definitions for some of the terms used in this report. They are presented here in a logical, rather than alphabetic order.

Hatchery - An enclosed facility managed for the purpose of retaining and growing a life stage of fish.

Hatchery fish - A fish that has spent any part of its life in a hatchery, recognizing there is a continuum of hatchery residency from days to generations. This would apply to eggs from wild parents incubated in a hatchery and stocked back into the stream, as well as to fish reared under several generations of hatchery selection (domestic strains).

Wild fish - Not a hatchery fish; generally the progeny of fish that spawned in the wild.

Native fish - A fish that inhabits a water **not** as a result of historical human intervention.

Transplant - The moving of wild fish from one system to another, without hatchery intervention as an intermediate step, in an attempt to solve or investigate a variety of problems (could be used as an alternative to hatchery fish).

Introduction - The planting of a species into habitat where it is not native. Introduced fish would not occur where they are found without historic human intervention.

Stock - A randomly breeding group of individuals that has spatial, temporal, or behavioral integrity from other randomly breeding groups of that same species.

Stocking - The physical act of putting fish into the water; either hatchery or transplants from the wild.

Supplementation - The use of artificial propagation or transplants in attempting to maintain or increase abundance of naturally reproducing fish populations.

Restoration stocking - The use of hatchery fish or transplants to attempt to reestablish extirpated native bull trout populations.

Harvest augmentation - The stocking of hatchery fish for the purpose of increasing fish harvest by anglers.

Put, Grow, and Take (PGT) - The stocking of hatchery fish with the sole purpose that fish being stocked will be caught by anglers.

Inbreeding depression - The reduction in fitness (ability to survive and reproduce) due to a loss of genetic variation.

Genetic reserve - A population of fish maintained under wild or hatchery circumstances to preserve the genetic diversity of a declining population.

BACKGROUND

Following is a discussion of some of the pertinent issues surrounding the use of hatchery fish and stocking (regarding recovery) as summarized from current literature.

Hatcheries and the ESA

Since the U.S. Fish and Wildlife Service has determined that listing of bull trout under the Endangered Species Act is "warranted", questions have arisen about the potential use of captive propagation for listed species. Hard et al. (1992) addressed this issue for Pacific salmon stocks. Under the Endangered Species Act (ESA), Section 3(3), conservation is defined to include:

> "...the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary. Such measures and procedures include, but are not limited to, all activities associated with scientific resource management such as research, census, law enforcement, habitat acquisition and maintenance, **propagation, live trapping,** and **transplantation....**" (emphasis added).

As stated by Hard et al. (1992): "The major constraints governing the use of artificial propagation in ESA Recovery Programs should be the maintenance of genetic and ecological integrity and diversity in listed species." That should be the goal for conservation of any native species, including bull trout. Hard et al. (1992) go on to say: "Artificial propagation of a listed species is not a substitute for remedying the factors causing or contributing to the initial decline, and recovery programs should reflect integrated planning that addresses these factors."

In this same paper, Hard et al. (1992) address the question of whether to use artificial propagation as a recovery tool. They state: "... a key factor to consider is the likelihood that artificial propagation will actually benefit the listed species. This evaluation must be made on a case-by-case basis. Attempts to increase natural production through the use of artificial propagation is a relatively recent enterprise that has to date produced mixed results. Therefore, the use of artificial propagation in ESA recovery plans should be viewed as an experimental technique."

Hard et al. (1992) further state that artificial propagation should be the first recourse only when extinction is imminent or when recovery in a "reasonable time" is not likely to result from addressing other factors such as habitat, harvest, land use, etc. Special cases may occur where vacant habitat is not likely to be recolonized due to straying or where habitat crucial to a portion of the life cycle is temporarily disrupted and artificial propagation may serve as a temporary means of conserving a natural population until the problem is corrected.

In any case, Hard et al. (1992) conclude that: "Artificial propagation under the ESA should be viewed as a temporary measure to be discontinued and all recovery options reevaluated if:

1. Artificial propagation is no longer believed to be necessary for timely recovery.

2. Naturally reproducing fish have risen in abundance above levels for delisting.

3 Appreciable differences between artificially and naturally propagated fish have emerged during a recovery program.

4. There is evidence that artificial propagation is impeding recovery."

The U.S. Fish and Wildlife Service has published a "Draft Policy Regarding Controlled Propagation of Species Listed Under the ESA" (USFWS 1995). The policy applies in Montana and, along with other regional USFWS policies, ensures that the principles outlined by Hard et al. (1992) and Steward and Bjornn (1990) are integrated in any program involving potential propagation of fish classified as Threatened or Endangered (see APPENDIX B). These same policies apply to "warranted" species, such as bull trout.

Uncertainty and Risk In Using Hatcheries

Uncertainty and risk go hand in hand. As in other activities where a biological resource is being manipulated, what we don't know is at least as important in shaping the program as what we do know and what we can control. This is because our ignorance often outweighs our knowledge about biological systems. It is the intent of the following discussion to present in general terms some of the known risks concerning the use of hatcheries. Their potential importance is further discussed under the strategies section.

The risks in using hatcheries in a species recovery program fall into two main categories; biological and social. Social risks (which are by no means confined to fish culture) include: false sense of security, diversion of funds from other management or restoration/recovery efforts, management by activity (rather than objective), and political abuse (public pressures). The biological risks discussed in this report are largely due to our lack of knowledge. These include: loss of genetic diversity within and among populations, interbreeding between hatchery and native fish, competition with or predation by hatchery fish, disruptive behavior, effects on non-target species, disease, depletion of wild populations for broodstock, and escapement from hatcheries.

The literature documents many negative biological effects of stocking hatchery-reared fish on top of wild populations. Marnell (1986) cites six categories of impacts, including: disease transmission, hybridization, trophic alterations, spatial alterations, changes in growth and survival, and displacement or elimination of wild fish populations. Recently, many authors have focused on the suitability of hatchery fish in the natural environment (Fleming and Gross 1992, Hilborn 1992, Irvine and Bailey 1992, Byrne et al. 1992, White 1992, Wiley et al. 1993, Stickney 1994). Some authors argue that by definition, hatcheries are not a natural environment. They contend that with fish confined at densities up to 600 times those under natural conditions it is in fact impossible to produce "natural" fish in a hatchery environment (White 1992; Byrne et al. 1992; Hilborn 1992).

However, reevaluation of hatchery procedures, changes in past practices, innovation in new designs, etc. are areas of current research interest and some authors believe that substantial gains in the suitability of hatchery fish can be achieved (Wiley et al. 1993; Stickney 1994; Beaman and Novotny 1994). While it should be relatively easy to make obvious "improvements" to the suitability of hatchery products, there is risk in thinking that the inadequacies of fish culture can be corrected. Wild populations maintain adaptive genetic diversity through natural selection, including their spawning behavior. Any form of artificial propagation that increases survival by reduction of natural mortality at any life history stage has the potential to change the genetic composition of the original stock.

Changing Roles of Hatcheries; Traditional, Mitigation, and Conservation

Much of the recent criticism directed at hatcheries is the result of a philosophical shift and experience in fisheries management. The "newer" conservation approach to management places a great importance on preservation of natural systems and their diversity (ecosystem approach). The older "traditional" approach to fisheries management emphasized recreational and commercial use of fisheries and little regard was given to ecosystem stability and diversity (Cuenco et al. 1993; Martin 1994). Historically, hatcheries played an important role in the user-oriented paradigm and many "desirable" species were widely introduced outside their native range with little consideration given to possible adverse effects to the native ecosystem.

Traditional hatchery uses have had profound, often negative, impacts on indigenous fish species. The current awareness of the value of native fish populations, both as entities adapted to local conditions and as genetic reservoirs for the future of their species, arose, in part, as a result of the disruptive aspects of species translocation.

Another common use of hatcheries is mitigation for habitat alteration (e.g. dam construction) or degradation (e.g. thermal increases) by constructing a hatchery that would raise either a native or introduced species for harvest augmentation. Although accepted scientific concepts of the day were considered in developing mitigation projects, they have clearly failed in many cases (NFHRP 1994). When mitigation hatcheries were built, the prevailing premise was that hatchery-produced fish of the same species could adequately replace natural reproduction lost when the habitat or access to the habitat was destroyed or changed. These policies de-emphasized the importance of appropriate habitat for the maintenance of viable populations (Stickney 1994).

The unreasonable expectations that hatcheries can somehow cure or overcome environmental degradation caused by dams, dewatering, and water pollution have lead to a great deal of confusion. Agencies responsible for fisheries resources have oversold this mitigation approach for decades.

Perhaps the most familiar example of hatchery mitigation is the program carried out by Columbia River Basin salmon hatcheries. In the early part of the century as the Columbia River was dammed and spawning habitat reduced, fisheries managers considered hatcheries as the best means to provide mitigation (Stickney 1994). As more dams were accompanied by decreased salmon returns to the upstream spawning grounds, mitigation hatcheries proliferated. Today, nearly 80 percent of Columbia River salmon (*Oncorhynchus sp.*) and steelhead (*O. mykiss*) start life in a mitigation hatchery (BPA 1987). In 1993, the National Fish Hatchery system produced over 50 million salmon and steelhead to supplement runs in Idaho, Oregon, and Washington; nearly 2.5 million pounds of fish in all (USFWS 1993b). However, as the numbers of hatchery fish increased due to the proliferation of hatcheries, salmon runs continued to decline (Nelson and Bodle 1990; Hilborn 1992). The same is true for Atlantic salmon (*Salmo salar*). In terms of mitigation, these programs are generally considered to represent large scale failures (NFHRP 1994).

Many programs failed, in part, by not adequately addressing stock identity and genetic concerns (Helle 1981, Larkin 1981). Although, the validity of the stock concept in salmonids has been recognized and reconfirmed for more than 40 years, it has not been integrated into the design of most salmonid culture activities (Helle 1981). The American Fisheries Society recognized that the "operational unit of concern for effective management" is the stock (genetically distinct units), not the species as a whole (Kapuscinski and Philipp 1988). As more information was gathered and tools such as electrophoresis and DNA sequencing became more commonly used to detect differences in stocks, salmon stocks became an ESA issue. Under the ESA, a distinct population segment (i.e., stock) may be considered as a "species" and qualify for listing. This has resulted in considerable review of salmon hatchery practices and adjustments are ongoing to protect native stocks.

The stocking of nonanadromous salmonids has taken place on a less coordinated scale through both state and federal programs. Successes and failures have been less thoroughly documented. Hatcheries have been instrumental in establishing populations of several strains of cutthroat trout (Gresswell 1988). In Montana, a large number of self-sustaining Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*) populations have been started by stocking hatchery fish in isolated, historically fishless, mountain lake watersheds. In many cases the populations were established with only one introduction. While these programs have benefitted anglers, the full biological implications of stocking fish in fishless waters are not clear.

This is not to say that hatcheries are "good" or "bad." The basis of western Montana's sport fishery today is a result of hatchery introductions. Rainbow (*Oncorhynchus mykiss*), brown (*Salmo trutta*), brook (*Salvelinus fontinalis*), and lake (*Salvelinus namaycush*) trout; yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), and largemouth bass (*Micropterus salmoides*) are all found in Montana as a result of "successful" hatchery programs or transplants. There is no simple, inherently "good" or "bad" label that can be attached to past hatchery practices. Rather, it depends on one's perspective and objectives. Stickney (1994) points out the need for collaboration and objectivity in future decision making and concludes:

> "Fisheries biologists owe policy makers and the public the assurance they conduct their science properly and will make recommendations based on hard data, not gut feelings or personal philosophy. Therein lies the opportunity to put the rancor and debate behind us."

Clearly, many of the current criticisms of hatchery practices stem from philosophical shifts and unclear management objectives. The Scientific Group recognizes this, but also makes the distinction between traditional/mitigation uses of hatcheries and the uses proposed for bull trout recovery. While many of the traditional uses of hatcheries have been discussed, they have been rejected as recovery strategies. These traditional uses were rejected primarily because they don't address the causes of decline and carry many of the risks discussed above, potentially exacerbating the decline. The hatchery strategies that the Scientific Group has embraced fit the concept of "conservation hatcheries" as discussed by Rinne et al. (1986). The main objective here is to protect and recover wild stocks and ultimately establish viable, reproducing populations.

The Stock Concept and Bull Trout

An understanding of the stock concept is critical in the evaluation of individual hatchery strategies for bull trout recovery. The stock concept states that a species is composed of genetically distinct units (or stocks) and that the stock, not the species as a whole, should be the operational unit of concern. Unique stocks are the result of evolutionary divergence, part of which may be due to the process of natural selection establishing local adaptations (Ricker 1972). Because local environments vary in physical, chemical, and biological characteristics, each environment has a unique set of attributes that imposes a different selection regime on the organisms that inhabit it.

Genetic risks to wild stocks increase whenever nonadaptive traits are selected in the hatchery stock, or genetic variation within the hatchery stock is small relative to the wild stock (Lannan and Kapuscinski 1984 *in* Steward and Bjornn 1990). However, the extent to which wild stocks are affected depends on the level of genetic dissimilarity, the reproductive contribution of hatchery and wild fish, the amount of interbreeding, and the relative fitness of progeny (Steward and Bjornn 1990). Waples (1991) notes that the widespread use of Pacific salmon hatcheries has had the effect of replacing a variety of stocks with a few generic types. Furthermore, he asserts that as the geographic distribution of genetically homogeneous hatchery stocks widens, the potential for harmful genetic interactions with genetically distinct wild stocks increases (Waples 1991). Thus, he concludes that the first guiding principle of any contemplated hatchery program should be: "First, do no harm."

Bull trout have specific requirements (usually associated with high quality habitat conditions) and are diverse in their life history patterns. Populations exhibit adfluvial, fluvial, and resident life histories and these patterns may overlap within the same drainage (Pratt 1992). These differences in life history embody the stock concept. Further, recent research on bull trout demonstrates that many, if not all, native local bull trout stocks are genetically different (Leary et al. 1993, Kanda et al. 1994, Williams et al. 1995). This diversity in stocks may be important for stability and resiliency of the species and for most efficient use of existing habitats for bull trout. Clearly, the stock concept applies to bull trout conservation and recovery and we must proceed cautiously when proposing the technical fixes that artificial propagation may provide. The Scientific Group feels that the genetic integrity of bull trout stocks must be further evaluated and we must learn as much as possible so that any activities that might disrupt stock genetics are not implemented.

In summary, we recommend a cautious approach due to the associated risks of stocking, the complex nature of bull trout and the fact that conservation hatchery practices are "new" science. Conway (1986), stated: "In the preservation of biological diversity, the use of technology is a last resort." According to Bella and Overton, quoted by White (1992), we may have created an "environmental predicament" where "man's ability to modify the environment increases faster than his ability to foresee the effects of his activities." It is the interaction between the habitat and the locally adapted fish which needs to be understood, protected, and restored. Natural restoration will follow on its own accord from protection, when abusive practices are eliminated. As stated by Rinne et al. (1986), "the role that hatcheries play in the recovery of rare fishes is only as good as the availability of suitable habitat in the wild for reintroduction."

STRATEGIES

The Scientific Group brainstormed potential uses of hatcheries or transplants and then condensed them into seven strategies involving the use of hatcheries or transplants in the recovery of bull trout. Each strategy was evaluated against a set of criteria and objectives (see APPENDIX A). Each strategy is presented independently with an analysis of its feasibility, benefits, risks, and recommendations the group has made.

<u>Strategy 1: RECOVERY WITHOUT THE USE OF HATCHERIES</u>

STRATEGY REJECTED

The Scientific Group felt hatcheries can be viewed as a potential tool for use in bull trout recovery when properly and judiciously applied. Rejection of the use of hatcheries may preclude saving the species or important subpopulations from extinction under the worst case scenario where a genetic reserve is required. The capability to perform certain types of research would be severely limited without the use of hatcheries. For those reasons, we feel it is appropriate to maintain the use of hatcheries as a future option for the recovery process and research.

<u>Strategy 2: GENETIC RESERVE</u>

STRATEGY APPROVED

A genetic reserve is a population of fish maintained under wild or hatchery circumstances to preserve the genetic diversity of a declining population. If extinction of a local population does occur, and subsequently conditions are again made suitable for bull trout, the reserve represents the most appropriate source for restoration attempts (Strategy 3). Much of the difficulty involved in the potential use of this strategy concerns selection of the appropriate level at which to implement it. Everyone agrees that it should be employed to save the species (e.g. California condors, black-footed ferrets). However, there is less agreement on whether the strategy should be employed at the stock or strain level, and even less concurrence at the watershed level.

The general view of the Scientific Group is that establishment of a genetic reserve would be a viable restoration strategy when trend data indicate a declining population, and extinction of a regionally important stock appears imminent. A feeling of imminent extinction would exist when the causes of decline are unknown or, if known, extinction is perceived likely to occur before there is enough time for positive response to remedial actions. Such decisions must include a careful analysis of trend data, genetic uniqueness, phenotypic (appearance) and behavioral aspects, and habitat considerations.

A genetic reserve is not without risks and these must be addressed if a reserve is to be established. First, the reserve must be founded from a sufficient number of individuals to ensure that the genetic diversity of the source population is adequately incorporated into the reserve. It is currently unproven what level constitutes the minimum number of founders required to ensure that substantial genetic differences are not immediately established between the reserve and source population. A minimum estimate is to use at least 25 males and 25 females (Allendorf and Ryman 1987).

In the case of a declining population, it will most likely be neither practical nor desirable to attempt to acquire gametes from 50 fish in a single season. Furthermore, removal of this reproduction could have an adverse impact on the native population. A solution is to attempt to acquire founders over a number of years (Leary 1991). Thus, if a reserve is deemed desirable it is important to establish it at the proper time.

There is also the risk that a genetic reserve may yield a false sense of security and become the sole restoration strategy. Once established, a reserve could serve as false rationale to not actively pursue identification and rectification of causes of decline. It is important to stress that the Scientific Group recognizes a reserve as a viable restoration strategy only when established in conjunction with actions aimed at ameliorating causes of decline in the wild. Preservation of a stock without future potential to reintroduce it into the wild is not an appropriate use of resources.

Another risk is that fish from the reserve may be used for inappropriate purposes simply because they represent a readily available source of fish. For example, there may be a desire to introduce them into waters that still harbor other native stocks of bull trout. If substantial genetic differences exist between the native and reserve fish, then interbreeding between them could disrupt local adaptations of the native fish and compromise their viability. The Scientific Group recommends that any stocking of reserve fish be subject to strict scrutiny before it is allowed to proceed.

Domestication represents a risk unique to hatchery fish. Domestication will occur because of selection for attributes more favorable to survival and reproduction under hatchery conditions. Through time this could result in establishment of substantial genetic differences between the reserve and source population, diminishing, from a genetics perspective, the value of the reserve.

The process of domestication can be retarded by a periodic infusion of genes from the source population into the broodstock. Domestication may also be reduced by changes in the hatchery management practices to try to create a more "wild" hatchery environment. If the source population does become extinct, only two options are possible. We can either compromise the reserve's genetic integrity by introducing genes from other native populations, or allow domestication to proceed. If it is believed that the causes of extinction can adequately be addressed within a couple of generations, then the latter is probably the better strategy. Again, these points stress that a reserve is only a valid restoration strategy when attempts are made to rectify causes of decline.

A potential risk of establishing a reserve in historically unoccupied habitat (i.e. a reserve or refugia in the wild) is that, if successful, the reserve may have adverse impacts on other native species (see Strategy 6). Before such a program is initiated, the Scientific Group recommends a thorough evaluation of the possibility of such impacts. If adverse impacts appear probable the program should not proceed.

Ultimately, the decision to establish a genetic reserve is a long-term commitment of manpower and resources and should not be taken lightly. There is likely to be a great degree of difficulty in determining when, and if, to proceed. A policy and an interdisciplinary oversight team should be developed to set forth a logical process addressing this issue statewide as well as regionally.

Strategy 3: RESTORATION STOCKING

STRATEGY CONDITIONALLY APPROVED

Restoration stocking has been defined as re-establishment of a self-sustaining bull trout population in habitat where they have been extirpated. It is accomplished by stocking with fertilized eggs or fish from appropriate donor populations. In general, the Scientific Group felt this would be a viable recovery strategy when a population of bull trout has been extirpated and the cause has been identified and eliminated. This strategy should be invoked only after the cause of extirpation has been eliminated and an appropriate amount of time has been allowed for natural re-colonization.

Identifying and using the most appropriate donor population is critical to this strategy. The donor population would come from either hatchery stock (if available) or from a wild population. If wild fish are used, the donor population should be evaluated based on genetics, life history, and habitat requirements. The risk to the donor stock must be considered of paramount importance. It is essential to choose a donor stock that has adaptive traits that are as similar as possible to those of the extirpated population. It is also desirable to match their genetic lineages if such information is available (Cuenco et al. 1993). The most appropriate wild donor stock may be the closest geographically within the same drainage, but this is not always the case. Other considerations would include evaluation of the carrying capacity and the potential for interspecific interaction and risks to other species.

Hatchery involvement might take two forms under this strategy; via the genetic reserve (Strategy 2), or in some cases it may be beneficial to bring wild eggs or fry into the hatchery and re-seed the vacant habitat with fry or fingerlings. The Scientific Group felt this strategy met the criteria as outlined (APPENDIX A) and would meet the objectives **only if** the threats to the population in the wild could be removed.

If successful restoration stocking occurs, the benefits are obvious. This sort of effort is easy to monitor and would likely have broad public support. Transplants from wild populations are relatively easy and cost effective. The risks associated with this strategy are mostly biological. The biological risks are associated with selection and protection of the appropriate donor population and potential impacts of mixing stocks of fish (straying of stocked fish). However, under some circumstances, the Scientific Group views restoration stocking as a viable recovery strategy.

Strategy 4: RESEARCH STRATEGIES

STRATEGY CONDITIONALLY APPROVED

The Scientific Group felt that the following strategies were more appropriately considered research rather than "recovery" strategies. Information gained as a result of such research may benefit the restoration effort. Generally, these strategies are experimental and do not meet the criteria for restoration of populations (APPENDIX A). Although research is valuable, it is usually expensive and time consuming.

Appropriate scale of such projects and proper scientific design are critical. Without proper constraints, these strategies may have unanticipated or negative side effects on other species within the ecosystem. The Scientific Group felt that the criteria for use of these strategies must be screened, involving the oversight of a technical committee. If an experimental program is conducted without proper design and monitoring, it may accomplish very little.

The following areas of discussion are not to be considered inclusive of all possible research, but represent areas that the Scientific Group saw as potentially useful. Because the interpretation of research and experiments is limited only by imagination, it is imperative that research proposals be peer reviewed by a technical committee. We recommend that the Restoration Team appoint this multi-disciplinary technical committee and that no experimentation occurs until it is in place and functioning. This review process could also serve by addressing many of the social risks described earlier, and by considering proposals in light of the overall recovery effort.

A. Experimental Stocking

Experimental stocking (hatchery or transplanted wild stock) is the use of fish to investigate limiting factors. This does not fit the definition of supplementation, because the objectives are very different. The primary objective of experimental stocking is to evaluate population limiting factors (bottlenecks), and secondarily, to augment a failing population by bridging a temporary limiting factor. This strategy would likely be employed in areas where bull trout have been extirpated or the population is determined non-viable. Uses might include assessment of restoration techniques, assessment of physical and biological parameters, and stocking to bridge a temporary habitat problem.

Any effort to move fish from a hatchery to the wild, or from one site to another in the wild, carries with it inherent risk. Screening criteria employed in the selection of projects that employ this strategy should include, but not be limited to: a defensible experimental design, genetic concerns, scaling the size of the project appropriately, an endpoint to the experiment, and adequate monitoring and follow-up (see APPENDIX B). This tool will be most useful on a site-specific basis where habitat or biological problems exist but are not clearly identifiable, and where those problems have potential to be solved if identified.

A further benefit of this type of research is to gain understanding of the life history requirements of bull trout. This knowledge can be applied on a broader scale. On a site-specific basis, it may allow us to find out what is "broken" so that efforts and funds applied to "fixing" problems are properly focused. Experimental stocking is relatively easy to carry out and monitor on a small scale and has potential to provide positive outcomes which can be incorporated into other restoration strategies.

B. Transplants for Breaking Down Inbreeding Depression

A potential side effect of population fragmentation is a reduction in population size and a loss of genetic diversity (Gilpin and Soulé 1986). Through time, the loss of genetic variation can result in inbreeding depression. Inbreeding depression is a compromise in a population's viability, due to a reduction in the ability of individuals to survive and reproduce (Allendorf and Leary 1986).

The quickest means of breaking down inbreeding depression is to cross individuals from the affected population with those from another population. This often serves to increase genetic diversity and restore developmental and physiological regulation, and increases the survival and reproductive capabilities of individuals (Dobzhansky 1970).

The most conclusive means of demonstrating that a population is experiencing inbreeding depression is to perform experimental matings. If, under controlled conditions, crosses between individuals from different populations have a lower proportion of developmental abnormalities, increased hatching success, or increased survival compared to crosses between individuals from the same population, then inbreeding depression has been demonstrated. An indirect means of determining whether a population may be experiencing inbreeding depression is observing that it possesses an unusually low amount of genetic diversity and that developmental abnormalities are prevalent (Leary et al. 1985). Evaluation of genetic diversity or developmental abnormalities alone would be inconclusive. It is possible for populations to have naturally low levels of genetic diversity and not experience inbreeding depression. Harsh environmental conditions can increase the proportion of developmental abnormalities (Leary et al. 1992). If harsh environmental conditions are the cause, then transplants will have little remedial effect.

The general view of the Scientific Group is that if a population has been demonstrated to be experiencing inbreeding depression (by experimental matings) or inbreeding depression is strongly suspected (because of low genetic diversity and a high incidence of developmental abnormalities), then transplants to increase genetic diversity using hatchery or wild fish are warranted. In the absence of such information, transplants are considered risky and should not be allowed to proceed. Potentially, unwarranted transplants will have little or no beneficial effect and represent a diversion of attention and resources. Furthermore, there is always the risk the transplants may disrupt local adaptations and reduce population viability. Note that, when experiencing inbreeding depression, a population has already lost any local adaptation, so local adaptations are no longer of concern.

In practicality, inbreeding depression is difficult to demonstrate and this experimental strategy is likely to be employed very rarely, if ever. Because of the uncertainties, this strategy is considered a research action.

C. Bull Trout x Brook Trout Hybridization

Hybrids between brook trout and bull trout are geographically widespread and at times locally common (Leary et al. 1983, 1993, 1995). Most of the hybrids are effectively sterile so they do not constitute a threat to the genetic integrity of bull trout populations. This does not mean, however, that the hybrids are benign with regard to bull trout population viability.

Evidence indicates that frequent hybridization can be followed by displacement of bull trout (Leary et al. 1993). It has been postulated that hybridization may play an integral role in this displacement. Hybrids represent wasted bull trout and brook trout reproductive efforts. It is believed that hybridization hinders bull trout more than brook trout. In migratory populations, where bull trout become sexually mature at a relatively advanced age (5-6 years), brook trout have a particular reproductive advantage.

Presently the extent of hybridization is determined by the detection of hybrid individuals. There are potential problems with this approach. If hatching success of the hybrid crosses is less than that of pure brook trout or bull trout, then the extent and potential adverse impacts of hybridization are being underestimated. Furthermore, if the hybrids, although largely sterile, frequently attempt to mate, then the impact of hybridization on bull trout will also be underestimated. Conversely, if the hybrids behave more like brook trout, and are nonmigratory, then capture methods might result in an overestimate of the problem when juveniles are sampled in streams that contain migratory populations.

The Scientific Group generally feels that experimental bull trout x brook trout matings are warranted. This strategy involves experimental hatchery-based research only, with no outplantings. This will also allow eventual assessment of the relative fertility of the known hybrid crosses. Overall, the results of such experiments will allow a better assessment of the potential adverse impacts of hybridization on bull trout population viability and possible need to remove brook trout (see Scientific Group Suppression/Removal report).

A risk of these experiments is the potential for escapement of the experimental fish, both bull trout, brook trout, and their hybrids, into a hatchery outflow. Extreme precautions should be taken in site selection and screening to minimize the possibility of escape.

Strategy 5: SUPPLEMENTATION

STRATEGY REJECTED

Supplementation, as defined by the Scientific Group, is the use of artificial propagation to maintain or increase an existing bull trout population. An important distinction between restoration stocking and supplementation is the stocking of hatchery fish into habitats **currently occupied** by bull trout. An example of supplementation is the current program practiced by many of the Columbia River Basin salmon hatcheries. Because supplementation is usually done on an annual basis, hatcheries are needed to implement this strategy.

We rejected the use of this strategy as a recovery strategy because it carries high risk (see Background section, this report), and is unsupported by the best available science. Supplementation has been defined in numerous ways, from a very narrow context which leads to the conclusion that true supplementation programs have seldom been implemented and even less seldom evaluated (Miller et al. 1990), to a much broader definition that leads to the conclusion that supplementation has been widely implemented and has generally failed (Winton and Hilborn 1994). However, because of questions regarding what it is, when and how it should be used, what its potential risks are, and whether or not it works, supplementation has become highly controversial (Reisenbichler and McIntyre 1977; Withler 1982; Smith et al. 1985; Fedorenko and Shepherd 1986; Miller et al. 1990; Solazzi et al. 1990; Steward and Bjornn 1990).

Most of the published information on salmonid supplementation comes from work on the Pacific coast with salmon and steelhead. Steward and Bjornn (1990) synthesized much of this literature. They cite the biological impacts of hatchery fish stocked on top of the same species of wild fish as including the potential for: (1) intra-specific competition for food and space, (2) predation on one another, (3) transmission of diseases or parasites to one another, (4) alteration of migratory responses, (5) competition for food resources in the nodal habitat, (6) redirection or amplification of predation or exploitation, and (7) influence of spawning success through differences in reproductive behavior, timing, and genetic exchange. Steward and Bjornn (1990) go on to say that many of the negative genetic and biological effects on wild populations remain largely unmeasured and theoretical. However, they state that:

"Supplementation, if done improperly, can be an added burden for native stocks attempting to adapt to significant environmental changes."

Miller et al. (1990) reviewed both published and unpublished works and came to many of the same conclusions. They advised: "Adverse impacts to wild stocks have been shown or postulated for about every type of hatchery fish introduction where the intent was to rebuild the run", and concluded examples of success at rebuilding self-sustaining fish runs with hatchery fish are scarce. Further, Miller et al. (1990) concluded: "No supplementation procedures should be attempted in wild/natural fish only streams." They recommend that monitoring of existing supplementation projects be stepped up, that a visual means of clearly identifying hatchery fish be developed so that hatchery and natural runs are managed separately, and that factors related to survival of hatchery fish be studied.

One potential benefit from supplementation is temporarily providing more fish for anglers. Because harvest is allowed, and is in fact directed toward hatchery salmon, harvest augmentation is the main benefit that salmon supplementation has provided for years. However, as discussed earlier, evidence of the biological impacts of this long-term salmon supplementation are only now being understood and documented. The relatively short-term benefit to anglers is likely far out-weighed by the risk to the species. This strategy further carries social risk; by providing higher numbers of fish, it may delude us into concluding the program has been a success at restoring the fish population.

In summary, bull trout supplementation was rejected as a recovery strategy because it is unproven, does not meet the criteria or objectives for recovery (APPENDIX A) and carries high biological and social risks, potentially doing more harm than good. Further, due to the high genetic and biological risks associated with supplementation on wild stocks, any current or planned supplementation efforts should be discontinued or screened in the same manner proposed for the research strategies so there is no threat to the bull trout recovery effort (APPENDIX B).

Strategy 6: INTRODUCTIONS TO EXPAND THE RANGE OR DISTRIBUTION

STRATEGY REJECTED

This strategy may involve stocking bull trout outside their native range, defined as all of western Montana and the Oldman River drainage east of the Continental Divide. An example of implementing this strategy would be the stocking of bull trout into waters that, historically, they did not occupy (e.g. Missouri River drainage). Use of this strategy would expand the range of bull trout. Hatcheries would presumably be the source for this expansion, but wild fish could be transplanted as well.

In general this strategy does not meet the Scientific Group's criteria and objectives of restoration (APPENDIX A). Risks include the alteration of other ecosystems and potential diversion of funds, resources, and attention away from restoration. Potential benefits include: high probability of some success and the possibility of benefiting anglers with increased bull trout fishing opportunities. The Scientific Group rejected this recovery strategy because it carries high biological risk.

A special case needs to be mentioned; that is, the potential to stock bull trout into waters within the existing range (western Montana) but upstream from natural barriers where they were not historically located. An example of such a location might be the upper Yaak River system. It was the consensus of the group that this type of introduction should never occur in fishless waters, due to the risk associated with introducing a major predator on top of amphibians, invertebrates, and other species. In waters where other introduced fish species already exist, this strategy may be considered on a case-by-case basis, and it may be appropriate to use such waters to establish a genetic reserve (Strategy 2) if all the implications are fully evaluated.

Strategy 7: PUT, GROW, AND TAKE (PGT)

STRATEGY REJECTED

Put, grow, and take (PGT) is a strategy involving the stocking of hatchery fish with the sole purpose of those fish being caught by anglers. As the title implies, the fish are typically stocked at an early life stage and are not caught or harvested until they have lived for a period of months or years in the water they are stocked into. This strategy would, by necessity, employ the use of a hatchery. Typically, PGT is employed in lakes or reservoirs.

The Scientific Group rejects this option as a recovery strategy. PGT does not meet the criteria the committee used to evaluate strategies (APPENDIX A). Biologically, there would be no benefit to the recovery of bull trout by implementing a PGT fishery. However, PGT may provide fish for anglers, and fill a social need. If PGT is implemented with proper constraints and on an appropriate scale, the impacts to recovery may be benign.

PGT could temporarily increase the number of bull trout available to anglers, since PGT fish would only be stocked in waters currently not inhabited by the species. This may result in increased angler opportunity to catch and, perhaps, harvest bull trout. With the proper educational emphasis, a PGT program may be useful in heightening angler awareness and support for the species and in mustering political support for recovery of wild populations. However, there is an inherent risk of misleading the public into believing that bull trout recovery has occurred, or is occurring, when in fact populations in the wild may be continue to decline. Potential biological risks include; genetic/fitness risk to wild populations of bull trout if employed in waters where interaction with wild populations can occur, disease transfer and unanticipated biological risks to the receiving waters.

Our information search turned up no examples where a PGT fishery has been developed using bull trout. However, where management PGT objectives can be met by using bull trout, the Scientific Group sees no problem when the biological concerns are addressed.

Should the Restoration Team endorse a PGT fishery (social or educational reasons), caution should be used in getting the right message across to the benefactors. In any case, PGT proposals should be screened in the same manner as research proposals (APPENDIX B) in order to address the above concerns. The Scientific Group rejects PGT as a restoration strategy and believes it is more appropriately an agency management tool than a recovery strategy, particularly in light of limited funding for recovery efforts.

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APPENDIX A

STRATEGY SCREENING CRITERIA AND OBJECTIVES

The Scientific Group identified and used the following criteria and objectives for screening various alternative strategies for bull trout recovery. It was agreed that each strategy we adopt should meet, at a minimum, the following criteria and objectives:

CRITERIA

- Is designed to provide for self-sustaining, resilient bull trout populations;
- Is implementable;
- Can be supported by the best available science;
- Is flexible enough to accommodate the goals of the individual basins;
- Recognizes the importance of broad, technical and public support;
- Is ecosystem friendly;
- Results in immediate, implementable standards and guidelines in addition to a long-term strategy;
- Recognizes the full spectrum of influences in the system;
- Is adjustable for local physical and biological conditions;
- Bases success on a watershed scale;
- Is conservative for bull trout so the result is meeting bull trout biological requirements;
- Has native species as its basis or primary motivation.

LONG-TERM OBJECTIVES

- Achieves a stable population;
- Provides the needed level of habitat/biological integrity to ensure persistence of existing populations;

- Achieves harvestable surplus populations in all 12 watersheds;
- Achieves a cost-effective system for bull trout recovery;
- Achieves short-term as well as long-term successes;
- Develops long-term public support;
- Finds solutions for causes.

INTERIM OBJECTIVES

- Removes the factors that are currently threats to bull trout recovery;
- Identifies and monitors the risk factors for bull trout;
- Provides a mechanism for focusing strategies on specific projects;
- Puts in place a mechanism to support adaptive management (defined as "learning from our mistakes");
- Builds accountability into the system through monitoring and evaluation;
- Achieves a net gain in the publics' knowledge and understanding of bull trout.

APPENDIX B

The Scientific Group reached consensus approval of the material presented in APPENDIX B. It should be noted that not all members agree with every item presented, or in some cases with the particular wording. It should be further noted that the Scientific Group feels hatchery-based experimental research or transplantation experiments using bull trout may have tangible benefits to management of wild populations. Concerns about political processes driving hatchery programs toward unwarranted expansion can be minimized by adherence to the following screening, performance, and monitoring criteria:

HATCHERY OR TRANSPLANT PROGRAM SCREENING CRITERIA

Any recovery-oriented hatchery program or experimental transplant involving the use of bull trout should be screened by an oversight committee appointed by the Restoration Team using the following seven criteria, as adapted from Cuenco (1994) and Steward and Bjornn (1990):

1. A genetic evaluation of both wild and hatchery stocks must be conducted prior to any stocking effort.

2. To reduce the potential for loss of genetic variation, maintain the largest effective population sizes possible in wild and hatchery stocks.

3. Appropriately scale any experimental stocking effort and ensure monitoring capability.

4. Reduce selection for hatchery-adapted traits and reduce hatchery conditioning (domestication) in any hatchery program or broodstock selection.

5. Maintain hatchery broodstock as a last resort. Utilize gametes from wild natural spawners whenever possible with due consideration to the wild source stock.

6. A fundamental goal of any stocking activity should be to recover the population to a level where stocking is no longer necessary.

7. Ensure that any actions that are experimental in nature are reversible, should unanticipated or potentially detrimental results occur.

PERFORMANCE STANDARDS

The four performance standards for evaluating success of stocking projects (RASP 1992) should be adopted for evaluating bull trout stocking. In summary, they are:

1. <u>Post-release survival</u> - measured from the time of release until adults spawn once.

2. Reproductive success - broadly defined as the number of offspring produced per spawner.

3. Long-term performance - defined as the capacity of a population to persist in the face of environmental variability and includes genetic concerns.

4. Biological interactions - defined as the affect the stocked fish have on the natural stream biota, including non-target species.

*Refer to RASP (1992) for more elaboration.

MONITORING AND EVALUATION CRITERIA

Because of the uncertainty and risk associated with using the proposed strategies the Scientific Group recommends the following, as a minimum level of monitoring and evaluation:

1. Clearly define objectives.

2. Identify performance measure(s) for each objective.

3. Develop experimental and sampling design.

4. Adjust or correct parts of the plan that are ineffective or inefficient in meeting the objective(s).

5. Review the adequacy of the monitoring and evaluation plan and modify accordingly.

6. Collect and analyze data.

7. Interpret results.

8. Summarize results, draw conclusions, publish in appropriate format, and distribute to peers (through scientific journals if possible).

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