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Alaska State Legislature

Legislative Research Agency

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September 11, 1991

MEMORANDUM

TO: Senator Lloyd Jones

FROM: Glenn T. Gray GTG
Legislative Analyst

RE: **Effect of Hatchery Salmon on Wild Salmon**
Research Request 91.303

You requested information about how hatchery-produced salmon affect wild stocks. You asked us to address five specific questions relating to this issue:

1) Do hatchery-produced fish cause genetic dilution of natural stocks?

2) Does the harvest of hatchery salmon result in unintended harvest of wild stocks?

3) Do hatchery salmon compete with wild stocks for food?

4) Is predation by hatchery salmon on wild salmon a significant threat to wild stocks?

5) Are wild stocks vulnerable to diseases that originate with hatchery-produced fish?

For this memorandum we reviewed studies by scientists from Alaska, other states, Canada, Japan, the Soviet Far East and Europe. We also reviewed abstracts of papers presented at recent conferences concerning the genetic implications of interaction between enhanced and wild fish. We then discussed these studies and related topics with several scientists and personnel from the Alaska Department of Fish and Game (ADF&G).

This memorandum begins by defining some important terms which are commonly used in discussions of salmon biology. Next, an introduction provides an overview of current knowledge of the effects of hatchery salmon on wild fish. Then each of the five questions you posed are addressed. We also identify other possible biological effects of hatchery salmon on wild stocks. This is followed by a discussion of how management can minimize possible negative effects of hatcheries. The memorandum ends with a summary of concerns voiced by biologists about hatcheries and research needs for the future.

DEFINITIONS

Biologists have traditionally recognized six species of **Pacific salmon:** coho (***Oncorhynchus kisutch***), chum (***Oncorhynchus keta***), chinook (***Oncorhynchus tshawytscha***), pink (***Oncorhynchus gorbuscha***), sockeye (***Oncorhynchus nerka***), and masu (***Oncorhynchus masu***). All but masu salmon may be found in Alaska waters. Recently, cutthroat trout (***Oncorhynchus clarki***) and steelhead (***Oncorhynchus mykiss***) have been reclassified as Pacific salmon. Atlantic salmon (***Salmo salar***) are not native to the Pacific, but some of them have escaped from fish farms in British Columbia.[1] **Salmonids** are a biological grouping which includes salmon species as well as related fish such as trout, char and whitefish. Most salmon are **anadromous**, that is they have both freshwater and saltwater residencies during different periods of their life. Some Pacific salmon spend their whole life in fresh water: **Kokanee** salmon are sockeye salmon that remain in lakes, **rainbow trout** are steelhead that live in lakes or streams, and **cutthroat trout** may also spend their life in fresh water.

We use the term **stock** to refer to groups of fish of the same species with a similar genetic background that return to spawn in the same locality, and do not generally interbreed with other groups of fish.[2] Some watersheds may have two or more salmon stocks, but these stocks usually spawn at different times or at different parts of the watershed.[3] Fish of a particular stock have a unique genetic make-up because wild salmon generally do not interbreed with other stocks. (As a result of natural straying, stocks spawning near each other would be expected to have more similar traits than stocks located further apart.) Some fishery experts prefer the term **population** because the term stock is often used in many different contexts. Alaska statutes, for example, define fish stocks less precisely.[4]

A **wild stock**, as used in this memorandum, is a distinct group of fish descended from a population of fish historically found in a particular area that have not bred to a significant degree with fish from another area.[5] A **natural run** is a self-sustaining group of "wild" fish in a natural environment that may or may not have genetic influence from hatchery or farmed fish.

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[1] Although Atlantic salmon have been caught in Alaska waters, there have been no reports of naturally reproducing populations.

[2] The term stock generally refers to wild fish because hatchery fish may have originated from several different stocks.

[3] Larkin (1981) notes that in some instances the "differences among the tributaries of a single river are greater than those among comparable tributaries of different rivers" p. 1460.

[4] Alaska Statute 16.05.940(15) defines a fish stock as "a species, subspecies, geographic grouping or other category of fish manageable as a unit."

[5] The Oregon Wild Fish Management Policy defines a wild fish as one that is descended from a population present in the same area since 1800.

A **mixed stock fishery** occurs when fish of different wild stocks or hatchery and wild stocks intermingle during commercial harvest. Many of the fisheries in Alaska are mixed stock fisheries. Fisheries that occur after stocks separate are known as **terminal fisheries**. In watersheds where several stocks spawn, individual stocks may not completely separate until they reach up-water spawning grounds. While terminal fisheries are desirable from a management perspective because stocks may be harvested selectively, they may not be economically desirable because the quality of the flesh deteriorates as the fish approach fresh water.

Genetic variability is measured by the "number, frequency, and diversity of alleles present. **Alleles** are the variant forms of the gene" (Kelly et al. 1989, p. 60). A procedure known as **protein electrophoresis** measures allele frequencies and can be used to identify different stocks as well as genetic changes these fish may experience.[6] Electrophoresis may also be used to measure **heterozygosity** (an indication of the variation of genes) to determine whether hatchery fish have lost genetic variability. Although electrophoresis is useful to determine a difference between some salmon stocks, the test does not reveal differences between all salmon stocks. Salmon stocks that cannot be differentiated by electrophoresis may be marked through a process known as **genetic tagging**.

Fisheries **enhancement** includes a variety of methods to augment natural runs. Hatcheries, construction of spawning channels, and lake fertilization are several examples of enhancement. Hatchery-produced fish are released to open water and are known as **ranched** fish; while fish raised in net pens and never released are known as **farmed** fish.

Fitness is the ability of fish to survive competition, predation and disease and return to native spawning streams. Some scientists suspect that wild fish are more fit than hatchery fish because wild fish have evolved through thousands of years of natural selection.

Brood stock are the fish used to start or maintain a hatchery. After salmon eggs hatch and their yolk sacs are consumed, the young fish are known as **fry**. When immature salmon migrate to the sea they are called **smolts**.

INTRODUCTION

Hatcheries have become a major contributor to commercial fisheries in the Pacific during the past two decades. As the numbers of wild salmon have decreased, Pacific Northwest states have become increasingly dependent on salmon produced by hatcheries. Except for masu and kokanee salmon, Japan depends almost entirely on hatchery stocks to supply its commercial fisheries

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[6] Electrophoresis works better with chinook and chum salmon than with sockeye, pink, or coho salmon (Seeb, personal communication).

(Kelly et al. 1989).[7] Although the Soviet Far East and Alaska still have many wild stocks, both have ambitious hatchery programs. For example, in recent years hatchery fish have comprised up to 98 percent of the total pink salmon harvest in Prince William Sound (Geiger et al. 1991). Despite the increasing contribution of salmon hatcheries, much is still unknown about the effect hatchery fish have on wild stocks. Additionally, some fear that the long-term productivity of hatcheries cannot be sustained (Hilborn 1990).

Each of the questions addressed in this memorandum are discussed separately, but they may actually be related, and addressing them separately may overlook cumulative impacts. For example, the genetic impact of straying salmon may be greater for a stock that has been reduced by over-fishing than for a healthy stock. Likewise, other influences of hatchery fish may have a detrimental cumulative effect when combined with practices destructive to wild fish (e.g., over-fishing and habitat destruction).

Most of the issues addressed in this memorandum ultimately relate to a concern about a reduction of genetic variability in wild salmon stocks. Genetic variability of a specific stock may be reduced when the size of that stock is significantly diminished. The numbers of a specific stock may be reduced by habitat loss, over-fishing, predation, disease, competition, and possibly by disturbance of wild fish nests (redds) by later-spawning salmon. Some geneticists believe that genetic integrity of a stock could also be at risk because of "genetic pollution" which occurs when hatchery fish breed with wild fish and introduce traits that may not be suited to a particular stream. Genetics most likely determine such traits as the timing of smolting, disease resistance, temperature tolerance, size of eggs, size of fish, timing of return, and possibly the ability of a salmon to find its natal stream. Because the brood stock for hatcheries are often obtained from distant watersheds, hatchery salmon may not be genetically suited for rivers near the hatchery. Hatchery fish which stray to local streams and spawn with wild stocks might introduce traits that would reduce the ability of wild salmon fry to survive in their natal stream.

During the 1970's, when Alaska's current hatchery program began, some biologists expressed concern about the risk to wild salmon of large numbers of hatchery salmon.[8] These concerns have been amplified in recent years. Several scientific conferences have convened to discuss the interactions of wild and hatchery salmon. A recent article by the American Fisheries Society's Endangered Species Committee identifies 159 West Coast salmon stocks at risk of extinction and 54 additional stocks of special concern (Nehlsen et al.

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[7] Attempts to develop natural runs of coho, chinook, and sockeye salmon in Japan have been unsuccessful.

[8] The Alaska District of the American Institute of Fishery Research Biologists issued a position paper concerned with genetic implications of hatcheries in 1975 (Attachment A). This organization was concerned that legislation creating private, nonprofit hatcheries did not address genetic issues.

1991).[9] Habitat loss, over-fishing, and negative interactions with hatchery fish were cited as the major threats to the wild stocks. The article notes that there is a high probability that 104 of these wild stocks have suffered genetic changes from the presence of hatchery fish.

Although researchers have recently placed more emphasis on studying the possible impacts of hatchery salmon on wild salmon, scientists debate the results of these studies. Many factors could be responsible for the decline of a salmon stock. Weak runs may result from habitat disturbance, over-fishing, disease, competition with other fish, or unsatisfactory environmental conditions, as well as a reduction in fitness from the influence of hatchery fish.

Even when evidence suggests that hatchery fish may have adversely affected a specific wild stock, it is difficult to generalize from that evidence about other stocks. First, each species of salmon has a different life history, different lengths of time in freshwater and marine environments, and different preferences for habitat and feeding.[10] Second, a study in one area may produce different results than if it was conducted in another environment or using different research methods. Third, the same study completed during separate years could have different results because of changing environmental conditions from year-to-year. Fourth, the location of a hatchery and its operating procedures will influence the effects of hatchery fish on wild populations. Fifth, the source of hatchery brood stock may determine the effect on local wild salmon. Sixth, different researchers may reach different conclusions from the same data. Lastly, there is often a shortage of baseline data on wild stocks (many significant stocks may not yet be identified), so it is difficult to measure changes that may occur.

Despite the gaps in scientific knowledge, there is consensus on at least two major points. First, fishery experts agree that in mixed stock fisheries where there are strong hatchery returns and weak wild stocks, wild stocks are likely to be over-harvested. Second, fishery geneticists generally agree that hatchery salmon have the potential to alter the genetics of wild fish. Researchers do not agree, however, if interbreeding between hatchery and wild fish will reduce the long-term fitness of wild salmon stocks. Likewise, there is not a consensus about how hatchery fish affect wild fish through competition, transmission of disease, and predation. Large-scale releases of hatchery salmon, however, are more likely to result in more profound effects on wild salmon than are releases of smaller numbers of fish.

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[9] Salmon stocks in California, Oregon, Idaho and Washington were examined in this study.

[10] Reimers (1979) reports that life histories of juvenile chinook salmon vary both within and among stocks although many managers fail to recognize such variation.

GENETIC DILUTION OF NATURAL FISH STOCKS BY HATCHERY-PRODUCED FISH

The genetic diversity of wild salmon populations in Alaska is the result of ten thousand years of natural selection.[11] Biologists assume that specific salmon stocks are best suited to their immediate native environment and that wide genetic diversity permits the stock to withstand extreme changes in environmental conditions. Wild stocks are "adapted to their local habitats, yet flexible enough to respond to future changes in these habitats" (Oregon 1990). The consensus among geneticists is that "fitness (reproductive potential) is enhanced by heterozygosity (genetic variability)" (ADF&G 1985, p. 14).

The subject of genetic dilution is further addressed under several subheadings: the lack of scientific consensus, evidence of reduced genetic variability, causes of reduced variability, interbreeding of hatchery and wild salmon, and evidence of a loss of fitness.

Lack of Scientific Consensus

While there is a general consensus among biologists that hatchery strays can affect the genetic make-up of wild fish, it is difficult to prove that such changes will reduce the fitness of a naturally spawning salmon stock. Kelly et al. (1989) surveyed salmon experts and found no "solid data base which could support a documented position (either pro or con) regarding the effects of interbreeding among wild and hatchery fish" (p. 83). Waples et al. (1990) state that compared to other management problems, there has been little effort to address the genetic aspects of salmon management. The current state of scientific knowledge is unable to bridge the gap between the ardent proponents of aquaculture and those who recommend a more cautious approach. Chettleburgh (1991) states that genetic pollution

> has become a rallying point for the opponents of aquaculture, particularly commercial fishermen and environmentalists who use the issue with impunity since it is almost impossible to prove or disprove. The effects, if any, may take centuries to occur. (p. 3)

Many scientists agree that literature on genetic impacts is not conclusive and "is largely speculative in nature and without much hard evidence" (Smoker 1985, p. 3). Poor returns can be blamed on over-fishing or bad environmental conditions (Helle 1981). Yet the increased attention given to the topic during the past few years reflects a growing concern by fisheries managers and

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[11] Two levels of genetic variation occur: differences between fish of the same stock and differences between different stocks (Oregon 1990).

scientists.[12] Those who encourage a conservative approach point out that loss of genetic variability that has evolved for thousands of years may be irreplaceable.

While some scientists are critical of hatcheries because of a fear that they may reduce fitness by altering genetic diversity, others are willing to accept some risks as long as production is increased (Mathisen 1991). As a result, different jurisdictions approach salmon enhancement from different perspectives. For example, while the Alaska Department of Fish and Game (ADF&G) Genetic Policy gives priority to wild stocks, Japan gives priority to enhanced fish.

Evidence of a Reduction in Genetic Variability

Several methods are used to determine the difference between hatchery and wild fish, including scale pattern analyses and starch gel electrophoresis of tissue proteins. Periodic genetic monitoring using electrophoresis can determine if there has been a change in allelic frequencies and therefore a reduction in genetic variability. These studies can reveal if there has been gene flow between a hatchery and wild population and if the genetic variability has been reduced. This process, however, does not reveal if hatchery-wild hybrids are more or less fit than the wild fish. In other words, geneticists can use electrophoresis to determine if a fish is a hatchery fish or a wild fish or if salmon stocks, such as hatchery fish, have lost genetic variability (assuming that the test recognizes a genetic difference between hatchery and wild fish and that electrophoresis data is available for the stocks before hatchery fish entered the gene pool).[13] With salmon stocks that do not show a discernable difference using electrophoresis, it may be necessary to use a marking program such as coded wire tagging to determine if hatchery fish are spawning with native fish.

Researchers from around the world have found a reduction of genetic variability in enhanced salmon. In Ireland, Whelan and McGinnity (1991) found that a rare allele has been lost in hatchery fish. Japanese researchers found that concerns about a reduction of genetic variability are supported by a decrease in the number of late run chums and odd-year pinks, reduction of variations in

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[12] The 1980 FAO-UNEP Expert Consultation on the Conservation of Genetic Resources of Fish, sponsored by the United Nations, was one of the first major conferences to deal with this topic. Several recent conferences include the April 1990 conference in Loen, Norway; the June 1990 NATO-sponsored Genetic Conservation of Salmonid Fishes in Moscow, Idaho; and the International Symposium on Biological Interactions of Enhanced and Wild Salmonids in Nanaimo, British Columbia. Dr. Ole Mathisen is planning a workshop on this topic to be held in Alaska this fall, and Dr. Tony Gharrett is organizing a panel discussion at the November 1991 meeting of the Alaska Chapter of the American Fisheries Society.

[13] According to Steer et al. (1991), there is a scarcity of data for wild stocks compared to enhanced fish.

the timing and duration of maturation of individual fish, and a reduction in the proportion of the effective number of breeding to total number of returning fish (Kaeriyama 1991). A Soviet Far East study of the Ochepukha watershed found that although selected breeding practices reduce the genetic potential of the hatchery salmon, researchers have not been able to detect any significant differences in abundance, size, weight or fertility of males between streams with only natural runs and those with both wild and enhanced stock (Shubin and Kaevo 1991). Ryman and Stahl (1981) report strong evidence suggesting that hatchery fish in Scandinavia have drastically changed the genetic composition of wild brown trout.

Causes of Reductions in Genetic Variability

Hatchery practices can lead to a reduction of genetic variability. For example, poor hatchery management could reduce the genetic variability through inbreeding or as a result of inadvertent or purposeful selection.

Inbreeding

Crossing salmon that are directly related to one another can result in a loss of genetic variability known as inbreeding. According to Smoker (1985), studies have shown that inbreeding is a distinct possibility in a hatchery.[14] Practices such as the use of a low male to female ratio or too few fish for brood stock may increase the possibility of inbred fish in future generations. The use of local wild stocks to periodically refresh hatchery populations is one way to avoid inbreeding. Studies have not yet documented inbreeding for Pacific salmon hatchery stocks. Riddell et al. (1991), however, speculate that inbreeding could account for reductions in body size of cohos. Waples et al. (1990) note that there have been no comprehensive attempts to determine if hatcheries have been successful in their attempts to prevent inbreeding. Inbreeding depression (loss of vigor) has been documented for some hatchery-raised trout species and Atlantic salmon (Kelly et al. 1989). This may be the result of using a small number of fish to start these hatcheries.

Additionally, studies have not documented a reduction in the average heterozygosity of a Pacific salmon hatchery stock when compared to the whole species (Kelly et al. 1989, Smoker 1985).[15] A lower value of heterozygosity

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[14] Smoker (1985) reports that a study has shown that with 50 spawners, a hatchery would lose 10 percent variability after ten generations and 25 percent after 20 to 30 generations.

[15] Unless studies have been completed for wild fish before genetic interaction with hatchery fish, comparing average heterozygosity of hatchery fish to that of "wild" fish may not be valid.

in Japanese chum salmon when compared with U.S. chum salmon suggests a loss of genetic variability for chum salmon in Japan.[16]

Selection

The rate of genetic change may increase dramatically in hatcheries through selection, which may be either deliberate or unintentional. Selection of large males and earlier-run salmon for hatchery brood stock has resulted in earlier runs of Sakhalin Island chum salmon. The fish are bigger but the rate of reproduction has decreased (Khorevin 1991). Larkin (1981) suggests that a change in traits of hatchery salmon is likely and selection over generations may explain a perceived decline in the fitness of hatchery stocks.

Some scientists recommend against intentional selection for hatchery fish for specific characteristics such as size, growth, and color (Krueger et al. 1981). The ADF&G's Genetic Policy recommends that brood stock represent a broad cross section of the genetic diversity of a run. However, Larkin (1981) suggests that selected hatchery stocks could improve wild stocks and that the "truth may well be that wild stocks improve hatchery strains rather than that hatchery strains dilute wild stocks" (p. 1473). He suggests that deliberate selection could also offset selection by the fishery, perfect transplanting techniques, and determine the timing of hatchery runs. Smoker (1985) also suggests that hatchery salmon could increase genetic diversity in stocks that have been decimated through over-fishing or as a result of natural population crashes. This is because a small escapement of such a stock could lead to inbreeding.

Actions of hatchery personnel or hatchery conditions may result in inadvertent selection. Hatchery-produced salmon may adapt to hatchery conditions which differ from conditions in the wild. To avoid selection of fish tolerant of hatchery conditions Krueger et al. (1981) recommend release of fish at an early age.

Spawning behavior in the wild involves an elaborate courtship ritual and an establishment of a hierarchy of males. Pink salmon tend to mate with similar sized mates and these progeny tend to be more viable than matings between fish of different sizes, as often occurs in hatcheries (Chebanov 1991). Thus, even random pairing of hatchery fish are likely to produce different pairings than what would occur naturally (Helle 1981).

Natural selection in hatcheries produce fish adapted to hatchery conditions which may not have survived in freshwater conditions (for those salmon that do not migrate immediately). If these salmon survive ocean conditions, they could stray to local streams and if successful at reproduction they could reduce fitness.

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[16] Japanese fisheries are almost completely dependent on hatchery production.

Interbreeding of Hatchery and Wild Fish

The increased straying of hatchery salmon, especially transplanted fish, can result in the transfer of ill-adapted genes. Large-scale hatcheries can be expected to have more strays than small-scale hatcheries (Smoker 1985).

Although it is known that salmon will stray to some degree, scientists do not agree about the degree straying occurs. We were unable to find many studies that predict a specific percentage of strays for either wild, hatchery or farmed salmon.[17] Gritsenko (1991) found that there is a significant increase in spawners due to straying from large rivers in the Okhotsk Sea coast of Sakhalin Island, but that there is poor survival of their progeny. Using a mathematical model, Zhivotovsky et al. (1991) found that straying between stocks had a significant influence on the dynamics of pink salmon populations. On the other hand, an Alaska study at Auke Creek suggests that pink salmon do not ordinarily stray in large numbers to nearby streams, and that there may be some degree of genetic isolation between runs that spawn at different times in the same stream (Gharrett and McGregor 1991). Other studies may not consider that pink salmon are known to test various streams before ultimately spawning in their natal stream (Gharrett, personal communication). Therefore, the extent of straying suggested by some researchers may be exaggerated.

Many authors report that transplanted and hatchery salmon stray more often than wild salmon. Helle (1981) reports that transplanted salmon have a reduced homing ability. Waples et al. (1990) think that straying rates may be higher for hatchery fish. Gausen and Moen (1991) found that greater numbers of escaped farm salmon spawn in rivers within twenty kilometers of a net pen facility. Bams (1976) conducted an experiment in British Columbia using transplanted pink salmon, hybrids of transplanted males and wild females, and wild salmon. He found that for a stream in British Columbia, transplanted salmon were the least likely to return to spawn. The hybrids were more likely to return, but the wild salmon had the best chances of returning. In a similar experiment, Smoker (1985) found that transplanted salmon may be more fit than transplanted-wild hybrids. The propensity of transplants to stray may mean that genetics play a role in the ability of pink salmon to return to their natal streams. Larkin (1981) suggests that the straying of hatchery fish may be due to rearing conditions instead of or in addition to genetics.

Although hatchery salmon may stray more than wild salmon, Soviet scientists Gritsenko and Kovtun (1991) think that locating a hatchery away from natural spawning areas can reduce straying and the impact of straying on the gene pool of wild stocks. The authors maintain that wild and enhanced fish can co-exist as two reproductively isolated groups.

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[17] A 1991 study by Hard and Heard that studied chinook returns from a fish hatchery in Little Port Walter that used trans- planted salmon. Of the 1.1 percent of the fish that strayed, approximately 1/3 of them strayed within 7 kilometers, almost 2/3 strayed less than 25 kilometers, and the most distant stray was 500 kilometers away. Curiously, none of them strayed to their original rivers which were 250 kilometers from the hatchery.

The ADF&G Genetic Policy acknowledges the potential of straying hatchery fish to reduce the fitness of the naturally spawning fish, but it also suggests that hatchery strays may have little impact on wild stocks.

The degree of interbreeding between hatchery and wild fish can only be detected if there is a significant genetic difference between the two. Studies have revealed little contributions by hatchery steelhead fish to wild fish in the Skagit River after twenty years of stocking. On the Yakima River, considerable introgression (introduction of genetic material from one gene pool to another) between hatchery and nonanadromous wild steelhead occurred, yet anadromous steelhead have shown little introgression with hatchery fish (Campton 1991). Hindar et al. (1991) cite several other studies that reveal introgression between hatchery or farmed salmonids and wild stocks.

Evidence of a Loss of Fitness

Some studies have shown that hybrids of wild and nonlocal salmon are less fit than their wild counterparts (Waples et al. 1990). Because many traits are thought to be inherited, biologists fear that hybrids will be less able to compete, less resistent to disease, and more vulnerable to predation. Allendorf (1991) points to the growing evidence of a loss of local adaptations. Larkin (1981) reports that some people suspect that declining success of hatcheries after a decade or so may be due to genetic changes. Hindar et al. (1991) state that a "considerable body of relevant indirect evidence" points to adaptive changes resulting from interbreeding (p. 950).

On the other hand, according to Kelly et al. (1989), some fishery specialists do not think that hatchery-wild hybrids will detrimentally affect wild stocks. Additionally, there is speculation that in some cases of over-fished wild salmon stocks, hatchery fish may actually increase the fitness of the wild stocks (Kelly et al. 1989; Larkin 1981). However, according to Davis and Burkett (1989), "[a]ny loss of genetic variation results in a loss of fitness, but any gain in genetic variation may or may not improve fitness" (p. 4).

Some researchers have found that wild smolts are more likely to survive than hatchery smolts (Hilborn et al. 1991; Whelan and McGinnity 1991). Swain and Riddell (1991) suggest that if hatchery fish mate with wild stocks, the offspring may be less fit than the wild fish, but that throughout time, wild fish stocks would likely regain fitness.

A study in Norway found that farmed brown trout males do not survive well in wild streams and that only a limited amount of spawning occurred between wild males and farmed females (Skaala et al. 1991). Flemming and Gross (1991) found similar results with hatchery-reared coho salmon in Vancouver Island, British Columbia. Hatchery salmon, especially males, did not reproduce well unless there were no fish in the stream. As the density of spawners increased, the reproductive success of the hatchery fish decreased. Hatchery fish that do breed in the wild could produce a genetically inferior fish. Reisenbichler and McIntyre (1977) revealed that hatchery steelhead were genetically different from wild steelhead and that they did not survive as well as wild fish.

Some studies using hatchery and wild fish from the same parents have found that the hatchery fish do not survive as well as wild fish in natural conditions. These results suggest that a reduction in fitness is a response to hatchery conditions rather than caused by genetics. A study using progeny of the same parents reared one group naturally and the other in the hatchery found that the hatchery group had a reduced osmoregulatory ability (i.e., diffusion of water through cell walls). Because both came from same stock, the difference was probably a response to the rearing environment (Shrimpton et al. 1991). Ward et al. (1991) found that pen-reared steelhead from wild parents survived at lower rates than wild steelhead.

Transplants

Hatchery salmon bred from salmon transplanted from long distances have a greater chance of being less fit than those bred from a local stock. The ADF&G Genetic Policy assumes that hatchery stock from a different geographic area could reduce fitness of a salmon stock, but it is not known if this reduction is critical (Davis and Burkett 1989). The policy suggests that it may be safe to transfer stocks from within the same region for brood stock (ADF&G 1985).

Many states, including Alaska, restrict the transport of live fish or gametes (eggs or sperm) to decrease the chance of spreading disease and to be sure fish used in hatchery operations are similar to local stocks. Recently, however, an increase of fish smuggling by aquacultural operators was reported in California (CAA 1990).

INCREASED FISHING PRESSURE ON WILD STOCKS

In a survey of fishery professionals about the effect of hatchery fish on wild fish, Kelly et al. (1989) found that the greatest consensus was that large-scale releases of hatchery fish can be detrimental to wild fish stocks if there is no feasible way to separate the fish before harvest. "Almost all hatchery-produced salmon in Alaska have the potential for engendering mixed-stock fishery management problems" (Smoker 1985, 14). Mixed stock fisheries are difficult to manage because there is a danger that the smaller stocks will be over-harvested. The state's mixed stock policy encourages terminal fisheries whenever possible (fisheries that occur after the stocks separate). It is not economically feasible to fish at many terminal fisheries because once salmon near their spawning area, the quality of their flesh declines as they adopt spawning characteristics.

While there is danger of over-exploitation of a weak stock in mixed stock fisheries, the problem is compounded with the addition of hatchery stocks (Smoker 1985). Hatchery stocks need less brood stock than wild fish, so it is possible to have a higher harvest rate for hatchery fish than for wild fish.[18] Especially with large-scale hatcheries, it is difficult to estimate the numbers of wild fish returning (unless they are separated physically or at the time of return). A certain number of wild fish are needed to sustain a stock's genetic variability.

The director of ADF&G's Division of Commercial Fisheries in 1982 explained that with fisheries enhancement, "[w]e may not be able to fully develop some sites and stocks without declines in natural stocks or foregoing harvests of enhanced stock unless we modify our current way of managing" (Pennoyer 1982, p. 113). Under mixed stock fisheries "stocks which are of consistently lower productivity will probably have consistently lower escapements and sooner or later will decline, often drastically, even with 'good management'" (Pennoyer 1982, p. 112).

Many examples document that optimum harvest of hatchery fish in mixed stock fisheries has occurred at the expense of wild fish. Because hatchery fish can withstand a higher exploitation rate than wild fish, wild stocks will be over-harvested unless the entire fishery is limited (Waples et al. 1990). An Oregon study found that the decline in abundance of wild coho salmon in the Columbia river coincided with a sharp increase in harvest rates. The study suggests that current harvest rates will result in the extinction of wild coho (Cramer 1991).

In the Baltic Sea, the number of natural Atlantic salmon drastically declined as a result of an off-shore fishery on mixed stocks (Eriksson and Eriksson 1991). Hilborn (1990) reports that high harvest rates of hatchery fish in the waters between British Columbia's Vancouver Island and the mainland has resulted in an increase in hatchery production, a decline in wild stocks "and the Canadians have no more coho now than they did fifteen years ago" (p. 3). Enhancement activities (new spawning channels) in Babine Lake of British Columbia's Skeena River basin significantly increased production at the expense of other basin stocks (Smoker 1985).

The risks inherent in mixed-stock fishing may be reduced if hatchery and wild fish spawn at different times. Although original hatchery stocks in Prince William Sound were selected to be later or earlier than the wild runs, there is some overlap. Wild stocks can be easily over-harvested at the entrance to the sound in areas where stocks are mixed, such as happened during 1990 (Geiger et al. 1991). According to Eggers et al. (1991), the recent decline in wild pink salmon in Prince William Sound is believed to be a result of low escapement due to over-fishing of wild stocks. Hatchery and wild stocks are harvested together "in the near-terminal mixed-stocks fishing areas and as cost

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[18] Optimum harvest rates for hatchery fish are 90 to 95 percent while optimum rates of harvest for wild fish are between 60 to 75 percent (Kelly et al. 1989). Hatchery production results in fewer mortalities than wild production because wild fish are subject to changing environmental conditions, competition and disturbance of redds by other fish.

recovery in the hatchery terminal harvest areas" (p. 4). The authors ascribe the low escapement of wild fish to "a weak implementation of the fixed escapement goal policy" (p. 27). In other words, in order to harvest the high numbers of hatchery-reared salmon before they lose quality, harvest rates of wild salmon in these fisheries have reduced the number of wild salmon escapement to levels lower than before the hatcheries were built.

To assess the pressure exerted upon wild fish, some method of identifying the numbers of wild and hatchery salmon must be used. Coded wire tags are sometimes inserted in juvenile fish. The coded wire tag program in Prince William Sound, however, doubled the cost of managing that fishery. A recently introduced marking method, known as thermo-marking, relies on distinctive markings on the fish's otolith (ear bone) as a result of different water temperatures in the hatchery. Each hatchery using this method uses a different sequence of water temperatures. Electrophoresis is another technique that can be used to separate stocks, although it has limitations. The lack of a marking program for hatchery fish from the Gastineau hatchery in Juneau made it impossible to determine if poor returns in 1989 were due to over-harvesting (Geiger et al. 1991).

Smoker (1985) recommends several possible solutions to reduce over-fishing of mixed hatchery-wild stocks: 1) identify the percentage of wild fish in the mixed-stock fishery and reduce catch levels to permit sufficient escapement of the wild stocks, 2) establish annual catch quotas for the fishery, 3) use hatchery stock that return at a different time than wild fish, and 4) restrict the numbers of hatchery fish produced. Smoker acknowledges the problems with each of these solutions.

COMPETITION FOR FOOD BETWEEN WILD AND HATCHERY-PRODUCED FISH

The issue of carrying capacity (the number of fish that can be supported in a given area) of salmon is still contentious. Inhibited growth of salmon due to competition with other fish is known as density-dependent growth. It is difficult to determine if density dependency is the cause of a reduced average size of salmon or if this reduction is a result of poor environmental conditions (e.g., less food sources due to colder water temperatures), or a combination of factors. It should be noted that even if density dependency is found to be an important factor in one area, it may not be as important in another area or at another time. Environmental conditions may be different during different years and in different places. Also, salmon of the same species may have different migration patterns in different areas.[19] Different

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[19] In the Soviet Far East, salmon from East and West Kamchatka spend about three months in coastal waters while those in southwestern Sakhalin Island spend up to five months in coastal waters (Karpenko 1991).

life histories of Pacific salmon species makes it difficult to generalize about density-dependency factors for all salmon.[20]

According to Peterman (1984), "[d]ensity-dependent growth or survival has been well documented for the freshwater life phase of Pacific salmon," but less is known about such limitations in marine waters. Given the lack of knowledge of density-dependent growth among wild fish, it is even more difficult to determine how important competition between hatchery and wild fish is. Many scientists suspect, however, that hatchery and wild salmon may compete for food in freshwater, in estuaries, in saltwater nearshore areas, and in the open ocean. Hatchery fish may also displace wild fish from their habitat during juvenile freshwater residence and during spawning (Hindar et al. 1991). Additionally, Kelly et al. (1989) report that some scientists believe that hatchery-wild hybrids may be less able to compete with other fish for food. The density-dependency dispute will only be answered by studies that span many years and consider a variety of factors including fluctuations in environmental conditions and the numbers of hatchery fish released. The discussion below centers on existing studies on this subject.

Competition in Freshwater

A Washington study in two rivers suggests that hatchery coho fry were better able to compete than wild fry. The production of hatchery fry increased, but the total number of fry living to smolts stayed the same. While the number of hatchery smolts increased, the number of wild smolts decreased (Seiler et al. 1991). Reisenbichler and McIntyre (1977) also found that hatchery fish released into stream systems may affect wild fish through competition for food and space. Lichatowich and McIntyre (1987) report that hatchery coho smolts displaced wild fry. Another Washington study, however, found that neither wild nor hatchery coho (from native stock) fry were affected by the presence of the other when released into four streams (Wampler et al. 1991). A study in France showed that if prey density is low, coho salmon escaped from farms could affect the density and growth rate of native Atlantic salmon (Beall and Heland 1991).

Competition in Estuaries

Some evidence points to density dependence in estuaries. Larkin (1981) notes that the unnaturally high numbers of hatchery salmon released at one time may displace wild fish at the site of release as well as in the estuaries and offshore rearing areas. Preliminary research in British Columbia estuaries reveals that migration of large numbers of hatchery-raised sockeye smolts may affect the growth and distribution of wild chinook fry in some estuaries. The researchers suspect that the limitations in the estuary may be due to space and food (McAllister and Levings 1991).

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[20] For example, pink and chum salmon immediately migrate to salt water and do not have competition pressures in freshwater. On the other hand, sockeye coho salmon may spend several years in freshwater and are therefore subject to different types of competition.

Competition in Nearshore Areas

Ocean survival may depend on nearshore competition. Bob Burkett, chief of technology and development for the FRED division places a high priority on studies concerning the nearshore carrying capacity (Gay 1991). Some salmon spend the early portion of their marine life in nearshore areas. Ivankov and Volkov (1991) found that competition for food is an important factor in early marine life survival for juvenile salmon. Karpenko (1991) found that the availability of food, determined in part by the numbers of juveniles, is a major factor determining survival of juveniles. An Oregon study that involved the review of demographic records of salmon stocks suggests that the carrying capacity of nearshore areas may be exceeded during some years. However, according to Smoker (1985), other authors have interpreted the same data and reached the opposite conclusion.

Eggers et al. (1991) acknowledge that it is possible that the nearshore carrying capacity of Prince William Sound may be nearly reached, but there "does not appear to be any competitive interaction between hatchery and wild stocks" (p. 23). Some people speculate, however, that the reduced size in salmon during the 1991 season was due to competition as a result of high hatchery production (Miller 1991).

Competition in the Ocean

Studies suggest that there may be density-dependent growth in the Gulf of Alaska. Peterman (1984) revealed that significant reductions in body sizes of adult sockeye salmon occurred during years of high numbers of sockeye salmon in the Gulf of Alaska. This study suggests that growth in the gulf is slowed during early ocean life and most likely results from "competition for food among similar-sized sockeye."[21] Eggers et al. (1991) report that a trend in decreasing average weight suggests that pink salmon growth in the Gulf of Alaska may also be density dependent, affected in part to increasing hatchery returns.

Studies in other parts of the world also suggest a relationship between high numbers of salmon and reduced growth. A Japanese study found that during the last decade of increased chum salmon hatchery production, salmon have decreased in size along with a decrease of the mean age at maturity. Stunted growth during the first year in the ocean suggests that the rate of growth decreased because of increased numbers of fish competing for food (Hayashizaki and Hitoshi 1991). Kaeriyama (1991) also suggests that a reduction in size and average age of adult chum results from density-dependent growth, but found little evidence that survival has declined (Kaeriyama 1991).

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[21] According to Peterman (1984) 80 percent of the sockeye in the Gulf of Alaska are from British Columbia and Bristol Bay. The density-dependent growth appears to be between fish of the same stocks as well as among sockeye from different origins.

Smoker (1985) modeled factors affecting ocean survival and found that large releases of hatchery salmon could not only result in a reduction of survival and growth but also could lead to increased variability of salmon abundance from generation to generation. While salmon may have more food available than they need in many areas, food may be patchy during their first summer at sea and "transitory limits to carrying capacity" may be important. Production of salmon has been more variable as hatchery production has increased in Hokkaido Island, Japan and in Oregon (Smoker 1985).

Ricker (1981) notes a decrease in the average size and age of Pacific salmon since the 1920s. He attributes this decrease to eight possible causes, including the possibility that some aspect of artificial propagation has caused slower growth.

Other studies suggest that density-dependent growth is unlikely. Smoker (1985) reports several studies that show no evidence that ocean growth is limited by density of the salmon. One of these studies simulated the growth and survival of salmon during the first six months of ocean life and found that more food is available to Pacific salmon than is consumed.

Should nearshore density-dependency growth be a threat, possible solutions include staggering the release of stocks and rearing salmon to a larger size before release. Future monitoring of growth, age and survival records will help determine where density-dependent growth appears to be a problem.

PREDATION ON WILD STOCKS BY HATCHERY PRODUCED FISH

Little is known about predation by hatchery fish. Generalities based on individual studies are problematic because of differences in the life histories of different salmon species (e.g., differences in freshwater residency, time spent in nearshore areas and ocean migration patterns). While there is evidence of predation by hatchery fish on wild salmon, wild salmon also target hatchery fry.

Ivankov and Volkov (1991) found that predation was an important factor in early marine life survival for juvenile salmon. Most knowledge of predation is in freshwater, estuaries and nearshore areas, and few studies quantify the loss of wild salmon by predation of hatchery fish (Smoker 1985). Hilborn (1990) states that hatchery fish pose a possible threat to wild fish by predation upon them. Smoker (1985) also suspects that enhanced fish may prey upon wild fish. Correlations between releases of hatchery salmon and declines in wild stocks have been observed. Hatchery releases of coho have been found to be coincident with decreases in pink and chum stocks in Washington. In another part of the state, delaying the release of hatchery coho until pink salmon migrated resulted in greater survival of pink salmon (Smoker 1985).

Coho salmon raised as smolts are known to feed on hatchery-produced pink salmon, and early predation in estuaries may be heavier than later predation. Additionally, large numbers of hatchery-released fry may attract coho salmon, which will feed on hatchery as well as wild salmon fry (Smoker 1985, Hindar et al. 1991).

Wood et al. (1991) found that declining sockeye returns to four lakes on Vancouver Island, British Columbia, were not a result of predation by hatchery smolts during the downstream migration. The researchers suspect that marine survival may be affected by predators attracted to nearshore areas because of the large numbers of juvenile salmon present there.

Karpenko (1991) reports that mortality of salmon due to predation varies from 1.5 to 52 percent in coastal waters of various regions. Fish, birds and marine mammals feed on juvenile salmon, but other species of fish (e.g., smelt, Arctic char and Siberian Char) are the most significant predators. Predation was found to be highest during the peak period of downstream out-migration for pink and chum salmon.

Some authors report predation upon hatchery fish as a reason for a reduction in hatchery fish. Beamish and Thomson (1991) report that in the Strait of Georgia, British Columbia, the average survival of hatchery coho and chinook were initially higher than that for wild fish, but after five years the survival rate decreased below historic levels for wild fish. The authors speculate that the cause of the decline in the survival rate may be due to a cyclic decrease in other food for predators so that they target hatchery fish. A Washington study suggests that hatchery fish may be more vulnerable than wild fish to predation by squawfish although the researchers concede that the higher predation may be because the hatchery fish were the most abundant prey (Fresh et al. 1991). One laboratory revealed that under pressure of predation hatchery chum had reduced feeding when compared to wild chum (Tompkins 1991).

THREAT OF DISEASE FROM HATCHERY-PRODUCED FISH ON WILD STOCKS

The threat of disease and parasites is twofold. First, a possible reduction of genetic diversity resulting from interbreeding with hatchery fish could make a natural population of salmon more susceptible to disease. Second, diseased hatchery stock could transmit the illness to wild stocks.

Few studies document the transmission of disease between hatchery and wild fish. However, Kitchell (1991) reports that hatchery-transmitted diseases may have led to the death of thousands of salmon in the Great Lakes. In a California hatchery, an unintentional cross between chinook and coho resulted in a hybrid that may have resulted in the first outbreak of IHN in coho (a viral disease lethal to hatchery chinook not normally found in coho salmon). None of these crossbreeds have been found returning to a hatchery, however (Bragg 1991). The ADF&G fisheries pathologist Ted Meyers knows of no instances in Alaska where hatchery fish have transmitted diseases to wild fish (personal communication). The ADF&G policy about the control of disease prescribes methods to reduce the transmittal of disease from hatchery-fish to wild fish (Attachment B).

The use of transplanted fish from one area to another can increase the chance of disease outbreak in the wild fish. For example, 23 wild stocks in Norway were decimated after the introduction of fish from the Baltic spread a parasite (Menke 1990). Smoker (1985) reports that researchers in Oregon speculate that transplanted coho may have weakened the ability of wild coho to resist the pathogen ***Ceratomyxa shasta*** in Nehalem Bay. Although transplanting fish from outside of Alaska is prohibited now, during the 1970s out-of-state chinook stock were raised in Ketchikan's Crystal Lake hatchery and in the Dredge Lake area in Juneau. The ADF&G terminated this project after the IHN virus infested the transplanted chinook salmon (Burkett, personal communication).

Captive fish are more susceptible to disease because of stress caused by the hatchery environment (FFTF 1990). There is some speculation that hatchery-wild hybrids may be less resistant to disease than wild fish (Kelly et al. 1989).

OTHER EFFECTS

Hatchery salmon may affect wild salmon in other ways not addressed above. Some professionals theorize that wild fish may follow hatchery fish as a result of a chemical (pheromonal) attraction (Kelly et al. 1989). A detrimental effect of hatchery salmon may result when late-spawning hatchery strays dig up the redds of the wild fish (Menke 1990). Additionally, in Pacific Northwest states some hatcheries that fail to produce adults must use wild stocks for a source of eggs and thereby present a net drain to already dwindling numbers of wild stocks (Hilborn et al. 1991). Over-exploitation of wild brood stock for a hatchery on Sakhalin Island in the Soviet Far East also resulted in destroying chum salmon runs from small brooks of the Tym River (Gritsenko and Kovtun 1991).

Recent experiments with gene transfer techniques could someday be used in commercial salmon hatcheries to produce faster-growing fish or ones with greater environmental tolerance. The American Fisheries Society has recommended that such fish not be used in aquaculture facilities without completion of risk assessment studies (Kapuscinski and Hallerman 1990).

An additional consideration relates to the effect large unharvested returns of hatchery salmon may have on wild salmon. During the 1991 season, a significantly large return of hatchery pink salmon returned later than normal but matured earlier than normal. As a result of market saturation, millions of these fish were not harvested. The effect of this large unharvested return is unknown and a few questions remain unanswered. Did hatchery fish displace wild salmon in local streams? Will there be a subsequent reduction of wild salmon in future years? Will there be a larger number of hatchery-wild hybrids? Although there are no funds allocated to study these questions, tissue samples from Prince William Sound rivers are being preserved for possible study in the future.

HATCHERY MANAGEMENT IMPLICATIONS FOR WILD SALMON

Proper siting of a hatchery along with good hatchery management and effective management of the commercial fisheries will reduce the potential for adverse biological interaction between hatcheries and wild fish. Conversely, improper siting and poor management practices will increase the risks of adverse interaction. The following discussion considers the effects of management in general and then provides an overview of management programs in Alaska and Pacific Northwest states.

Sound Hatchery Management Practices

According to Helle (1981), the location of a hatchery is the most important factor that will help maintain wild populations. Hatcheries must be able to separate wild and enhanced stocks either through time or space. General consensus among biologists is that large-scale hatcheries can potentially wield more damage to wild stocks than smaller facilities. Larkin (1981), however, notes that in some cases large centralized hatchery facilities may be practical.

Other potential problems resulting from hatcheries may be minimized by following specific procedures. The risk of losing genetic variability in hatchery salmon can be reduced by using a large founder population, random pairing representing a wide cross section of the local run, avoiding intentional selection, and crossing wild and hatchery fish every season (Kelly et al. 1989). Although there is no official policy for renewing hatchery stocks Menke (1990) claims that

> Alaska fisheries officials agree that it may be a good idea to renew hatchery production with wild eggs and sperm on a frequent cyclic basis, perhaps every four years or so (p. 50).

Some scientists recommend that wild salmon mating behavior be emulated as much as possible (e.g., use as high a ratio of male to female fish as occurs in the wild). Hatchery and wild fish can be kept genetically similar by initially using local brood stock and by periodically renewing hatchery stock with local fish.

Maitland et al. (1981) recommend the establishment of a worldwide system to identify and monitor wild salmonids. They suggest that a group such as the International Union of Nature and Natural Resources (IUCN) undertake this project. Others advocate the creation of areas known as genetic sanctuaries to protect significant salmon stocks. Enhancement activities would be prohibited in these areas (FFTF 1990; Helle 1981, ADF&G 1985).[22]

Waples et al. (1990) recommend that programs be expanded to identify different genetic stocks, monitor genetic changes in hatcheries, and evaluate the consequences of proposed large-scale enhancement programs. Kelly et al. (1989) recommend meticulous record keeping for hatcheries about such topics as breeding practices, disease resistance and average heterozygosity. Use of recently developed thermo-marking techniques may eventually make it feasible to mark all hatchery fish and determine the extent to which salmon stray.

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[22] No gene bank programs for salmon are officially recognized in the U.S. (Kelly et al. 1989).

Other management initiatives may become important in the future. Release of sterile hatchery salmon may be used to prevent hatchery fish from affecting the gene pools of wild stocks.[23] Sperm from fish can be stored (cryopreserved), but preservation of eggs or embryos has not yet been accomplished (Thorgaard and Cloud 1991).[24] Wildt and Rall (1991) warn that such techniques should not be used as a "quick-fix" but instead be used along with other conservation techniques. Norway's gene bank program involves the deep freeze of sperm and establishment of living gene banks in brook stock-stations. The program began in an effort to preserve genetic material before the genetic make-up of wild fish were negatively affected by fish farm strays (Gausen 1991). Gene banks have also been established in the Soviet Union (Helle 1983).

A paper by the American Fisheries Society recommends federal regulation of salmon and steelhead hatchery programs to preserve existing genetic diversity (Nehlsen et al. 1991). The authors think that federal regulation now could reduce future listings of stocks as required by the Endangered Species Act.

Alaska Hatchery Management

Because management can minimize or exacerbate the negative impacts of hatcheries, some discussion of Alaska statutes, regulations and policies is appropriate. However, a critique Alaska's hatchery program is beyond the scope of this memorandum.

The intent language of the 1974 legislation authorizing private nonprofit hatcheries reflects a priority for wild stocks.

> The program shall be operated without adversely affecting natural stocks of fish in the state and under a policy of management which allows reasonable segregation of returning hatchery-reared salmon from naturally occurring stocks (Chapter 111 SLA 1974).

Alaska Statute 16.10.400 states that the ADF&G commissioner will not issue a hatchery permit unless the hatchery "would result in substantial public benefits and would not jeopardize natural stocks." Other statutes do not show a clear preference for management of wild stocks over hatchery salmon (White, personal communication; Utermohle, personal communication).

Alaska statutes direct ADF&G's Division of Fisheries Rehabilitation, Enhancement and Development (FRED) to complete state and regional plans. Alaska Statute 16.05.092(1) requires the FRED division to "develop and

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[23] Sterile triploid brook trout are recommenced by Corely-Smith et al. (1991) to protect their genetic material. Triploid fish can be created by using heat treatments or by crossing tetraploid females with diploid males. Seeb (1991) reports that the British Columbia government is considering the use of sterile net pen fish to prevent escapees from spawning with wild fish.

[24] Alaska is using sperm cryopreservation for fish on the Chilcat River (Seeb 1991).

continually maintain a comprehensive, coordinated state plan for the orderly present and long-range rehabilitation, enhancement and development of all aspects of the state's fisheries . . . and revise and update this plan annually." Alaska Statute 16.10.375 mandates the completion of comprehensive salmon plans by regional planning teams. State statutes also require each hatchery to complete an annual report including information about the brood stock used (AS 16.10.470).

The ADF&G regulations seek to minimize adverse impacts of hatcheries. For example, regulations specify that during the application phase for hatchery construction, regional planning teams review permit applications including provisions to protect natural stocks (5 AAC 40.170), a public hearing is held, and the department reviews the permit to be sure that hatchery returns will not "unreasonably or adversely affect management of natural stocks" (5 AAC 40.220). Regulations also mandate that hatcheries complete an annual management plan that outlines production goals, brood stock management and the management of the harvest of hatchery returns (5 AAC 40.840). A performance review is also required that evaluates the effect of the hatchery on natural stocks (5 AAC 40.860). Regulations require that a fish transport permit be obtained before transporting live fish within the state (5 AAC 41.005), and prohibit the importation of live fish from outside the state (5 AAC 41.070). Regulations also mandate disease control and inspection (5 AAC 41.310).

The ADF&G policies also address hatchery management. A 1982 draft manual of policies and procedures for the nonprofit hatchery program was never approved, but some of the policies were codified in regulation (ADF&G 1982). The Genetics Policy, is one of the most important current policies about hatcheries. This policy, a policy about disease and a policy about permitting nonprofit salmon hatcheries in Alaska are contained in Attachment B.

The ADF&G's Genetic Policy was created to "protect the genetic integrity of important wild stocks."[25] An eight-member team of public and private salmon experts produced the most recent version in 1985, but the policy is currently being reevaluated. The policy gives first priority "to protection of wild stocks from possible harmful interactions with introduced stocks." Comments by ADF&G officials have, however, indicated that preference could be given to

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[25] The Finfish Farming Task Force (1990) alleged that the policy is not always rigorously enforced and recommended that an ad hoc committee be appointed to assess compliance with this policy. The task force also recommended that guidelines in the policy be codified in statute.

hatchery stocks in certain situations.[26] The Genetic Policy also recommends that:

- stocks should not be transported between the large geographical areas of the state (no maximum distance is identified),
- donor stock should be physically similar to local stocks but local stocks are preferred,
- significant wild stocks should be identified, and watersheds with such stocks should only be stocked with progeny from indigenous fish,[27]
- wild stock sanctuaries should be established where enhancement would be prohibited,[28]
- a single donor stock should not be used for more than three hatchery stocks, and
- a minimum effective population of 400 brood stock should be used to develop and maintain hatchery stocks.

The second portion of the policy describes current knowledge and uncertainties about the effects of hatchery fish on wild fish.

The State of Alaska addresses the impact of hatcheries on wild stocks through statutes, regulations and policy, but some ADF&G commercial fisheries personnel have suggested changes. Geiger et al. (1991) recommend establishment of clear guiding principles for the hatchery program. The authors suggest that production-based objectives are in conflict with preservation of the genetic integrity of wild stocks and the reduction of fishing effort on specific wild stocks. Eggers et al. (1991) argue for an integrated management system "to

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[26] Kelly et al. (1989) report that the commissioner of ADF&G in 1981 stated that ". . . in some instances ADF&G would consider carrying out a program to purposely alter a wild stock for the benefit of a hatchery stock, provided circumstances indicate that the best interests of both the public and the resources would be served" (p. 30). The director of the Division of Commercial Fisheries in 1981 stated that "[c]onscious trade-offs of weak or smaller natural stocks may be justified by the magnitude of enhancement opportunity, but this cost must be carefully measured" (Pennoyer 1982, p. 113).

[27] The team did not define "significant stocks" but instead left it to the Salmon Enhancement Regional Planning Teams to define this term. To date, significant stocks have not been identified.

[28] At this time, there have been no formal designations of wild stock sanctuaries or conservation areas. A formal policy is currently being written that will outline procedures to establish such sanctuaries (Burkett personal communication).

meet dual objectives of protecting wild stocks and hatchery cost recovery/brood stock needs" (p. 30).

Wild Salmon Management in Other West Coast States

Severely depleted runs of wild salmon in Pacific Northwest states have prompted proposals to classify some of these stocks as endangered species. Fishery scientists there have a growing concern about the role of hatcheries in the depletion of natural runs. Accordingly, Oregon responded to the decrease in wild salmon by creating its Wild Fish Management Policy in 1990 (Attachment C).[29] The policy mandates that the Department of Fish and Wildlife identify all salmon populations (stocks) in the state. The policy also prescribes specific standards to protect wild salmon,

Other jurisdictions approach wild fish management in a variety of ways. Idaho gives first consideration to wild fish if there is a conflict between the two, and it gives priority to preserving genetic integrity over maximizing harvest potential. Washington has allocated 25 percent of Puget Sound for hatchery salmon, but the rest of the sound is managed for wild fish (Hindar et al. 1991). British Columbia classifies streams in three categories ranging from management for wild salmon (with some hatchery production) to streams managed for hatchery fish (Kelly et al 1991).

SUMMARY

The cumulative effect of habitat destruction, over-fishing and large-scale hatcheries has lead to the decimation of many wild salmon stocks in Pacific Northwest states. Biologists in states with a long history of hatchery programs are generally less enthusiastic about these programs than biologists in areas such as Alaska and British Columbia with comparatively recent programs. Although poor hatchery practices can clearly endanger wild salmon populations, scientists do not agree on the extent to which hatcheries with sound practices can coexist with sustained healthy runs of wild salmon.

Current Knowledge About the Effect of Hatcheries

Little is known about the interactions of hatchery and wild fish, but most scientists agree that hatcheries can complicate mixed stock fisheries and affect the genetics of wild fish stocks. Scientists do not agree on the degree such genetic changes will affect the fitness of wild stocks or if long-term fitness will be affected at all. Those who think that hatcheries negatively affect wild salmon generally agree that small-scale, strategically located facilities using local stocks will minimize the effects. Many biologists think that the biggest threat to wild fish occurs in areas where there are extremely

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[29] The policy, written in the form of regulations by the Oregon Fish and Wildlife Commission, is an enforceable standard of law.

large releases of hatchery fish that will compete with, predate upon, or mate with wild fish.

The lack of consensus among scientists results from a lack of data and research, but even where information exists, it is often subject to different interpretations. To complicate matters, results of specific studies may not be transferable to other areas or other salmon species, and year-to-year environmental changes may affect the results of these studies.

Genetic Ramifications

Scientific knowledge about the genetic impact on wild stocks of hatchery fish is still incomplete. Reduction in the fitness of salmon stocks, to the extent it has been documented, may involve numerous factors. Many studies report that hatchery fish are not as fit as wild fish both in juvenile residence in freshwater and during spawning. However, it is unknown if the long-term fitness of wild stocks will be affected, and some researchers think that observed reductions in hatchery fish may be the result of rearing conditions rather than genetics. Without baseline studies and adequate long-term monitoring, genetic changes are difficult to prove. Many researchers have noted a lack of emphasis in genetic studies, especially those that compare hatchery fish to wild fish. For many areas, including Alaska, not all significant wild stocks have been identified.

Scientists assume that wild stocks are the best suited to their stream of origin. Because many traits are thought to be inherited, biologists fear that hybrids will be less able to compete, less resistent to disease, and more vulnerable to predation. Such traits as egg size (evolved to reflect local conditions of stream substrate) and temperature tolerance are thought to be inherited. Some geneticists speculate that the homing ability of salmon may be a heritable quality. Thus, it may be important to keep hatchery salmon as genetically similar to local wild salmon as possible, and the practice of transporting brood stock even within a region may be detrimental. Additionally, the location of hatcheries where enhanced fish can easily stray to native streams may be detrimental to wild stocks (hatchery fish appear to be more likely to stray than wild fish).

Studies of hatchery salmon that measure genetic variability by average heterozygosity fail to show a significant loss of variability. The average heterozygosity of Japanese salmon, however, is below the U.S. average and this may indicate a loss of variability. Additionally, inbreeding has resulted in a reduction of variability for some other hatchery salmonids.

To complicate matters, some scientists doubt that hatcheries cause a loss in fitness of wild salmon. Some speculate that hatchery salmon could add variability to some wild salmon stocks.

Over-harvest of Wild Stocks

There is a general consensus among scientists that large-scale releases of hatchery salmon endanger wild stocks when returning hatchery fish are harvested in mixed stock fisheries with wild salmon. Some speculate that wild fish may be chemically attracted to hatchery fish and therefore school with them. Almost all Alaska fisheries had some degree of mixed stocks even before current hatcheries began operation. Smaller stocks are always in danger of depletion in mixed stock fisheries because there is a tendency to optimally harvest the larger stocks before they lose commercial quality at the terminal fisheries.

Competition

Some scientists suspect that the carrying capacity of freshwater rearing areas, nearshore waters, and on the high seas for salmon may be exceeded by the large-scale releases of hatchery salmon. A reduction in the average size of salmon has been reported throughout the Pacific, but various factors may be responsible. Some researchers believe ocean conditions affect the size of salmon more than competition. Much evidence, however, supports the theory of density-dependent growth for some salmon species during their rearing in freshwater. Some researchers also suggest that density-dependent growth occurs in estuaries, nearshore areas and in the ocean. Several studies suggest that density-dependent growth of sockeye and pink salmon occurs in the Gulf of Alaska.

Predation

Much is unknown about predation by hatchery salmon, but the greatest potential danger appears to be from the release of large numbers of coho smolts. There is speculation that large releases of hatchery fry may attract wild coho that will also feed upon wild fry.

Disease

Few studies document the transmittal of diseases between hatchery and wild salmon and there is no documentation of such transmittal in Alaska. Where transmittal of a disease by hatchery salmon has been documented, it occurred after fish were transplanted long distances. Hatchery fish appear to be more vulnerable to disease than wild fish because of the stress of hatchery conditions and large concentrations of eggs and fry.

Other Effects

Hatcheries may affect wild stocks in several other ways. Late-spawning hatchery strays may disturb the redds of wild fish. In the Pacific Northwest, there is some concern that unsuccessful hatcheries are resulting in a net drain when they use brood stock from depleted wild stocks. In the future, the use of salmon genetically altered to provide certain characteristics may affect wild stocks. Lastly, the long-term effects of millions of unharvested hatchery pink salmon is unknown.

Tasks for the Future

Many tasks face scientists, managers, and policy makers during the coming decade. Such challenges include setting research priorities, minimizing possible impacts, and reviewing current practices and policies.

Setting Research Priorities

A major challenge for the next decade will be to obtain a consensus about research priorities concerning the interaction of hatchery and wild fish in Alaska. Coordination of studies among university researchers, commercial fisheries managers, federal and state government scientists, hatchery personnel, and fishermen may also be useful.

The current lack of knowledge includes an absence of information about a variety of issues: the degree that wild stocks school with hatchery fish, migration patterns of wild and hatchery fish, the percentage of hatchery and wild fish that stray, the reproductive success of these strays, the carrying capacity of marine and freshwater environments, harvest alternatives for mixed stock fisheries, ways to emulate mating behavior of wild salmon in a hatchery setting, cryopreservation techniques for eggs and embryos, and the effects of large-scale escapement of hatchery salmon. Without a better inventory of significant wild stocks and constant monitoring of their fitness, the long-term effects of enhancement may not be known until it is too late to correct them. Cataloguing genetic characteristics of significant stocks will provide baseline data for future study of the effects of hatchery salmon. Better knowledge in these areas will permit policy makers to make informed decisions and to consider the risks associated with various decisions.

Minimizing Impacts

Although the effects of hatcheries on wild fish are uncertain, the risk of such effects warrant a cautious approach. Rather than more studies, Hindar et al. (1991) think that the current knowledge of the effects of cultured fish on wild fish is enough to call for immediate action. The authors cite recommendations from symposiums on this subject. Practices that will reduce such impacts include siting hatcheries where hatchery fish will have minimal opportunities to interact with wild fish as well as specific prescriptions that will keep hatchery fish as genetically similar to wild fish as possible.

Reviewing Current Practices and Policies

Some fishery specialists recommend approval of new or expanded hatchery operations on a case-by-case basis only after a thorough examination of possible effects. Many researchers emphasize that hatcheries should strive for an optimum annual production rather than maximum production. Others suggest that further expansion of hatchery programs be delayed until more is known about the their effects (Mathisen 1991). Hilborn (1990) recommends that there be a moratorium on the construction of new hatcheries and that hatcheries that cause adverse impacts on wild fish be closed.

Alaska statutes, ADF&G regulations and department policies contain many procedures to protect wild stocks. However, we were unable to locate any thorough studies that evaluate how well the current hatchery program protects wild salmon from possible negative effects of hatchery salmon. Such a review would help policy makers determine the risk of various alternatives for the future of Alaska's hatchery program.

I hope this information is useful. If you have any questions or want additional information, please contact this agency.

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ATTACHMENT A
1975 Position Paper of the Alaska District of the American Institute of Fishery Research Biologists

ALASKA CHAPTER

GENETIC CONSIDERATIONS IN ARTIFICIAL PROPAGATION OF SALMONIDS

WHEREAS throughout North America there is an accelerating interest in artificial propagation as a means of supplementing our natural salmonid stocks, and an urgent need exists for special planning regarding genetic considerations in artificial propagation of salmonid fishes; and

WHEREAS need for genetic planning exists in all salmonid enhancement programs in North America; and

WHEREAS it is desirable to maintain existing wild stocks in concert with artificially propagated stock through:

(1) location of sites for artifical propagation with regard to indigenous wild stocks, so that the adaptive genetic diversity of wild stocks will not be lost or diluted by chance interbreeding with cultured stocks,

(2) management of fishing pressure so as not to endanger reproduction of wild stocks,

(3) recognition of the potential behavioral and genetic stresses on native fishes caused by transplant stocks; and

WHEREAS it is also desirable to maintain adaptive genetic diversity in most artifically propagated stocks through:

(1) use of sufficient numbers of females and males in brood stock to avoid inbreeding depression problems,

(2) avoidance of selective breeding except in special situations or when used as a research technique: Now, therefore, be it

RESOLVED, That enhancement or rehabilitation of salmonid stocks in a stream or lake system should utilize native stocks already present; and be it further

RESOLVED, That in special situations where no alternative to transplantation exists, the characteristics of the donor stock be carefully matched so as to be compatible with the new environment; and be it further

RESOLVED, That the biological impact of transplantation on stocks of fish present in the recipient and surrounding watersheds be thoroughly evaluated; and be it further

RESOLVED, That artificially propagated stocks should be isolated (in time and in space) from wild stocks to allow effective management of fishing pressure on both types; and be it further

RESOLVED, That all agencies involved in enhancement and management of wild and cultured stocks of salmonids evaluate their present policies with respect to conservation of genetic diversity in wild stocks; and be it further

RESOLVED, That copies of this resolution be forwarded to agencies involved in artificial propagation and enhancement of salmonid fishes.

RESOLUTION

AMERICAN FISHERIES SOCIETY

Presented at American Fisheries Society
Detroit, Michigan September 22, 1976

Genetic Considerations in Artificial Propagation of Fishes

WHEREAS throughout North America there is an accelerating interest in artificial propagation as a means of supplementing our natural stocks, and an urgent need exists for special planning regarding genetic considerations in artificial propagation of fishes; and

WHEREAS need for genetic planning exists in all fish enhancement programs in North America; and

WHEREAS it is desirable to maintain existing wild stocks in concert with artificially propagated stocks through:

(1) location of sites for artificial propagation with regard to indigenous wild stocks, so that the adaptive genetic diversity of wild stocks will not be lost or diluted by chance interbreeding with cultured stocks,

(2) management of fishing pressure so as not to endanger reproduction of wild stocks,

(3) recognition of the potential behavioral and genetic stresses on native fishes caused by transplant stocks; and

WHEREAS it is also desirable to maintain adaptive genetic diversity in most artificially propagated stocks through:

(1) use of sufficient numbers of females and males in brood stock to avoid inbreeding depression problems,

(2) avoidance of deleterious selective breeding: Now, therefore be it

RESOLVED, That all agencies involved in enhancement and management of wild and cultured fish stocks evaluate their present policies and implement appropriate practices with respect to conservation of genetic diversity in wild stocks; and be it further

RESOLVED, That copies of this resolution be forwarded to all state, provincial, and federal agencies involved in artificial propagation and enhancement of fishes.

ATTACHMENT B
ADF&G Policies Relating to Hatcheries

Alaska Department of Fish & Game

GENETIC POLICY

by

Genetic Policy Review Team

Bob Davis - ADF&G, FRED, Chairman

Other Team Members:

Brian Allee - PWSAC, Cordova
Don Amend - SSRAA, Ketchikan
Bruce Bachen - NSRAA, Sitka
Bill Davidson - SJC, Sitka
Tony Gharrett - UAJ, Juneau
Scott Marshall - ADF&G, Comm. Fish
Alex Wertheimer - NMFS, Auke Bay Lab

Approved: Don W Collinsworth

Don W. Collinsworth, Commissioner
Alaska Department of Fish and Game

Date: 6·11·85

TABLE OF CONTENTS

INTRODUCTION

Alaska's valuable salmon industry relies on production from wild systems and, increasingly, on fish produced by aquaculture programs. The importance of maintaining healthy wild stocks and implementing successful enhancement activities underlies the need for an effective genetic policy. The genetic guidelines created to steer Alaska's aquaculture efforts were established in the mid-70's and have been reviewed to ensure that they reflect current knowledge, and goals. A revised genetic policy has been established that contains guidelines, supporting information and recommendations.

The genetic policy contains restrictions that will serve to protect the genetic integrity of important wild stocks. Certainly in Alaska where wild stocks are the mainstay of the commercial fishery economy, it is necessary to protect these stocks through careful consideration of the impacts of enhancement activities. Another important aspect of the genetic policy is the orientation towards increasing the productivity of enhancement programs in the state. Adherence to the guidelines will help maintain adequate genetic variability ensuring that the enhanced stock will be able to adapt to changing environmental conditions. The policy also includes considerations for selective breeding for desirable characteristics.

Due to the limited amount of information available on the genetic impacts of salmon enhancement on wild stocks, much of the basis for these guidelines is theoretical or based on work done with other species. Consequently, the most important considerations used in writing the guidelines are presented as a mechanism for illustrating the intent of the policy. An understanding of the rationale behind the policy is imperative to its effective application to individual cases under the very diverse conditions found in Alaska.

The importance of the genetic guidelines will continue to increase as aquaculture activities expand their production. This policy represents a consensus of opinion and should continue to be periodically reviewed to ensure that the guidelines are consistent with current knowledge. By doing so, we will be able to meet the goal of greater fish production through enhancement while maintaining healthy wild stocks.

POLICY STATEMENT

I. Stock Transport

A. Interstate: Live salmonids, including gametes, will not be imported from sources outside the state. Exceptions may be allowed for trans-boundary rivers.

B. Inter-regional: Stocks will not be transported between major geographic areas: Southeast, Kodiak Island, Prince William Sound, Cook Inlet, Bristol Bay, AYK and Interior.

C. Regional: Acceptability of transport within regions will be judged on the following criteria.

1. Phenotypic characteristics of the donor stock must be shown to be appropriate for the proposed fish culture regions and the goals set in the management plan.

2. No distance is set or specified for transport within a region. It is recognized that transplants occurring over greater distances may result in increased straying and reduce the likelihood of a successful transplant. Although the risk of failure affects the agency transporting the fish, transplants with high probability of failure will be denied. Proposals for long distance transport should be accompanied by adequate justification for using nonlocal stock.

II. Protection of Wild Stocks

A. Gene flow from hatchery fish straying and intermingling with wild stocks may have significant detrimental effects on wild stocks. First priority will be given to protection of wild stocks from possible harmful interactions with introduced stocks. Stocks cannot be introduced to sites where the introduced stock may have significant interaction or impact on significant or unique wild stocks.

B. Significant or unique wild stocks must be identified on a regional and species basis so as to define sensitive and nonsensitive areas for movement of stocks.

C. Stock Rehabilitation and Enhancement

1. A watershed with a significant wild stock can only be stocked with progeny from the indigenous stocks.

2. Gametes may be removed, placed in a hatchery, and subsequently returned to the donor system at the appropriate life history state (eyed egg, fry or fingerling). However, no more than one generation of separation from the donor system to stocking of the progeny will be allowed.

D. Drainages should be established as wild stock sanctuaries on a regional and species basis. These sanctuaries will be areas in which no enhancement activity is permitted except gamete removal for broodstock development. Use of such reservoirs for broodstock development should be considered on a case-by-case basis, and sliding egg take removal schedules applied to such systems should be conservative.

E. *Fish releases at sites where no interaction with, or impact on significant or unique wild stocks will occur, and which are not for the purpose of developing, rehabilitation of, or enhancement of a stock (e.g., release for terminal harvest or in landlocked lakes) will not produce a detrimental genetic effect. Such releases need not be restricted by genetic concerns.*

III. Maintenance of Genetic Variance

A. Genetic diversity among hatcheries

1. *A single donor stock cannot be used to establish or contribute to more than three hatchery stocks.*

2. *Off-site releases for terminal harvest rather than development or enhancement of a stock need not be restricted by III.A.1, if such release sites are selected so that they do not impact significant wild stocks, wild stock sanctuaries, or other hatchery stocks.*

B. Genetic diversity within hatcheries and from donor stocks

1. *A minimum effective population (N_e) of 400 should be used for broodstock development and maintained in hatchery stocks. However, small population sizes may be unavoidable with chinook and steelhead.*

2. *To ensure all segments of the run have the opportunity to spawn, sliding egg take scales for donor stock transplants will not allocate more than 90% of any segment of the run for broodstock.*

GUIDELINES AND JUSTIFICATIONS

I. Stock Transport

A. Interstate: It is generally accepted that population of salmonids which have existed over many generations in a given watershed have evolved traits that make them best adapted for survival in that environment. The greater the distance that a population is transferred from its native environment or the greater the difference in environmental conditions between the donor and transplant stream, the less likely the genetic characteristics of the population will fit the new environment. If the fitness of the population is indeed reduced in the new environment, then the probability of the transplant succeeding would be affected. In addition, interbreeding of a transferred stock with indigenous stocks could transfer gene traits that would reduce the fitness of the native populations. In many states, discrete stocks cannot be identified because excessive movement and interbreeding have already occurred. The State of Alaska, therefore, desires to protect and develop local stocks by restricting the movement of live fish or eggs into the state. There are, however, several trans-boundary rivers penetrating British Columbia, Canada, that flow into the state of Alaska. In some instances, donors from these stocks might fit a well-designed management plan.

B. Inter-regional: The environment can vary greatly from one region to another in a state as large as Alaska. For similar reasons given in I.A. above, the transfer of fish from one region to another is restricted. Consideration may be given to regional border areas, especially when no suitable donor stock is available within a region.

C. Regional: Although it is recognized that indigenous stocks are best for donor stock development, there have been numerous successful transplants, especially if the environment at the new site is similar to that of the donor stock and distance between the sites is not great. There is insufficient scientific data to predict how far or how diverse the environment must be before a negative impact will occur. However, it is believed that within a region site matching opportunities may be available. As site matching characteristics decrease and transplant distance increases within the regional borders greater justification is required for the proposed transplant. The following should be considered when selecting a donor stock:

1. Matching: Phenotypic characteristics of the donor stock should be matched to the environment at the site and to the management goals. Water chemistry and temperature profiles should be considered. Island stocks should be matched to other islands or to short rivers of comparable characteristics where possible. Time of spawning and fry emergence should be matched or compensated with the hatchery temperature required. Any deviations should be addressed and justified in the permit application or the annual management plan.

2. Migration Routes: The probable migration routes and potential user groups should be identified. The applicant must determine a probable migration route based on the migration route of the proposed stock and characteristics (topography) of the transplant site. Coded wire tagging of hatchery releases can determine the accuracy of migration route predictions as well as assess possible impact on local stocks.

II. Protection of Wild Stocks

A. Prevention of detrimental effects of gene flow from hatchery fish straying and interbreeding with wild fish.

Straying of hatchery fish released at the hatchery or off-station can potentially impact the fitness of wild fish populations through interbreeding of wild and hatchery fish. This assumes that hatchery and wild fish are adapted to different environments and either would presumably be less fit in the environment of the other and that hybrids would be less fit for either environment. Wild stocks have presumably been rigorously adapted to their native environment. Because of the large number of loci involved in the adaptation, many "successful" combinations of genetic information are possible along with the enormous number of "unsuccessful" combinations. Hybridization between discrete populations may produce a stock that has reduced fitness and therefore reduced production. Hatchery fish have been subjected to selection pressure for survival within artificial culture regimes, and may also have been originally derived from another stock adapted to totally different conditions than the impacted wild stock. Continued influx of hatchery fish together with the return of hybrids may alter the wild gene pool, reduce stock fitness, and thus threaten the survival of the wild population.

An alternative perspective is that hatchery strays will have little genetic impact on wild stocks. The influx of new genetic material through straying is a natural process in the development and expansion of salmon populations. If adaptation of the natural population is indeed very specific and selection is intense, then selection will favor and maintain the genetic complex of the wild populations. If adaptation is less specific and less intensive, then the genetic impacts from gene flow are insignificant. It is true that some straying occurs among adjacent wild populations and in most cases has occurred for a long enough time that such populations are quite similar genetically. However, situations in which transplanted stocks are involved are not analogous, as transplanted stocks would be less similar and gene flow would have a more profound effect. It is also true that the impact of introgression into the wild gene pool of genes from fish transplanted from a radically different environment may be limited by natural selection. Again the situations of concern do not necessarily lie near this extreme; hybrids and strays may be fit enough to dilute or replace the wild genome. Inherent homeostatic mechanisms for gene expression may compensate for some genetic influx.

The magnitude of straying relative to the size of the wild run is the most important criterion, as massive spawning by hatchery strays may jeopardize a wild population by displacement on spawning habitat and superimposition of redds, as well as, genetic influx. A conservative management approach dictates avoiding release sites where large numbers of hatchery strays can be expected to interact with significant or unique wild stocks. This approach can be achieved by spatial or temporal isolation of the hatchery and wild stock.

B. Regional designation of significant and unique wild stocks.

The magnitude of salmon populations varies between watersheds from intermittent runs maintained by straying to hundreds of thousands of fish. In evaluating the impacts of salmon enhancement projects, consideration must be given to the potential of detrimental effects from straying and intermingling with wild populations and possible resultant loss of wild production. Such consideration must take into account the benefits of the enhancement activity and the significance of the wild stocks impacted. Designation of criteria for runs of fish that are considered significant would greatly expedite the evaluation process. However, "significance" must be defined not only by the magnitude of the run, but also in the context of local importance and utilization. A small sockeye salmon stock near a village in southeast Alaska may be "significant", whereas the same size population may be too small to be considered a manageable entity in Bristol Bay. Because local utilization is an important concern, a regional planning group such as the Salmon Enhancement Regional Planning Teams, should consider what criteria will be used to determine significant stocks within a region and recommend such stock designations.

C. Stock rehabilitation and enhancement.

1. A watershed with significant wild stocks can only be stocked with progeny from the indigenous stocks. Rehabilitation of a watershed implies that there is insufficient production in habitat that formerly maintained a stock of some magnitude. Unless the indigenous stock has gone to extinction, use of an exogenous stock has potential for genetic damage noted in II.A. This damage will be exacerbated by the imprinting and homing of the transplanted stock to the impacted watershed, and potential displacement of wild

juveniles by the exotics stocked in the rearing habitat.

Enhancement of habitat not naturally accessible to salmon involves stocking eyed eggs, fry, or fingerlings, thus gaining production from this unutilized habitat. Where the inaccessible habitat is located above barriers on watersheds that maintain significant natural populations, stocking nonindigenous populations again has potential for genetic impacts noted in II.A., exacerbated by imprinting and homing of the transplanted stock to the watershed. For both rehabilitation and above barrier stockings, use of the indigenous stock alleviates these concerns.

2. When enhancing a stream using the indigenous stock, the fish used for stocking shall not be removed from the wild system to a hatchery for more than one generation.

   Hatchery incubation and rearing select for a limited set of biological and behavioral traits which are not necessarily the most suitable for survival in the wild environment. Because of this potential for such selection, the transfer of hatchery fish to rehabilitate or enhance stocks in depleted or underutilized watersheds runs the risk of altering the genetic character of the wild stock, even if the indigenous stock was the original donor stock for hatchery population. By restricting the separation between the transfer to the hatchery and the stocking to no more than one generation (e.g., eggs taken in a given year are cultured to fry or fingerling release at the hatchery; eggs or fish from the returns to the hatchery of this donor transplant are used for stocking), the risk of negative effects due to selection in the hatchery are minimized.

D. Establishment of wild stock sanctuaries.

As noted in preceding sections, there is concern that hatchery culture of salmon through their freshwater (and in some cases, initial estuarine) life history phases may select for a limited set of biological traits that are not suitable for wild populations. Loss of genetic variability through intensive inbreeding for domestication and desired traits has often resulted in detrimental genetic effects in agronomy and agriculture, such as reduced resistance to disease or adverse environmental conditions. Original wild strains can provide the genetic variability needed to outbreed domestics and alleviate inbreeding depression. Because there is potential for detrimental impacts due to reduction of genetic variability, there is a need to preserve a variety of wild types for future broodstock development and outbreeding for enhancement programs. Designation of watersheds where hatcheries or hatchery plants are not allowed would allow wild stocks within these watersheds to be subjected to natural selection only, within the life history phases cultured at hatcheries. These watersheds would be "gene banks" of wild-type genetic variability.

III. Maintenance of Genetic Variance

A. Genetic diversity among hatcheries.

There is general agreement that by introducing and maintaining a wide diversity of wild donor stock populations into the hatchery system that the prospects for long term success of the hatchery program in Alaska will be enhanced. Diversity tends to buffer biological systems against disaster, either natural or man-made. Developing and maintaining hatchery broodstock from a wide variety of donors will buffer the hatchery system against future catastrophes. Agricultural crop production in the U. S. provides a prime example of the dangers of genetic uniformity.

In an effort to increase yield, plant breeders have come to rely on a few highly productive strains. In 1970 approximately 15% of the corn production in the United States was lost to corn blight. The corn blight responsible, a mutant of the normal blight causing fungus, did not attack all strains. Only one strain of corn was vulnerable, but that strain of corn was grown by nearly every farmer in the country. Breeders were able to recover from the corn blight epidemic by replacing Texas cytoplasm with normal cytoplasm. Recovery was rapid because adequate genetic variability was available. There are other examples.

How does this relate to salmonid culture? Salmonid stocks apparently differ in levels of disease resistance, temperature tolerance, acid tolerance, and in their response to artificial selection. It seems imprudent to assume that conditions similar to those found in agriculture will not occur in aquaculture. In addition, the ability to genetically improve hatchery broodstock performance in the future will depend on the availability of genetic variability such as is found among wild salmonid stocks. A hatchery system with a variety of diverse broodstocks will be a valuable resource.

Genetic diversity does not guarantee protection from disaster, but uniformity seems to invite catastrophe. Local failures are inevitable within the hatchery system. It seems prudent to provide the system with a level of insurance by developing and preserving diversity among hatcheries.

Off-site releases for terminal harvest, whether for the commercial fishery or for a put and take sport fishery should have no adverse genetic effect if they are released at sites selected so that they do not impact significant wild stocks, wild stock sanctuaries or other hatchery stocks. The success of this type of release from a genetic standpoint depends on the ability to manage and harvest the return. If returns can not be harvested, increased straying may result which might lead to an impact on wild stocks at a greater than expected distance from the release site.

B. Genetic diversity within hatcheries and from donor stocks.

There is a general consensus among geneticists that fitness (reproductive potential) is enhanced by heterozygosity (genetic variability). Any loss of genetic variation will be accompanied by a concomitant reduction in fitness. Genetic variation allows a population to adapt to a changing environment or to adapt to and colonize a new environment. Available genetic variation determines how rapidly a population will respond to either artificial or natural selection. On the other hand, selection, inbreeding and random genetic drift will reduce genetic variability in a population.

Natural selection, that is selection for fitness, is a continuing process and should not be so intense that it has a significant effect in reduction of genetic variation, unless the population is in a new and quite different environment. Artificial selection on the other hand can be very intense, but can either be avoided or designed to assure that possible negative effects to fitness are offset by increased production efficiency due to the selection program, and by more efficient culture techniques. Inbreeding due to the deliberate mating of related individuals can be easily avoided in salmon hatcheries. Undoubtedly, in hatcheries and possibly in natural stocks the most important cause of loss of genetic variation is random genetic drift. In hatcheries reduction of genetic variation caused by inbreeding and genetic drift can easily be avoided by using adequate numbers of spawners.

Random genetic drift in general refers to fluctuations in gene frequency that occur as a result of chance. Such fluctuations occur, especially in small populations, as a result of random sampling among gametes. The amount of change but not the direction of change, can be predicted. The rate of this change is related inversely to effective population size (N_e). The smaller the effective population size the greater the fluctuation in gene frequencies. In small populations random genetic drift can result in inadvertent loss of genetic variability which may significantly reduce the fitness of the population.

Effective population size (N_e) is defined as the size of an idealized population that would lose genetic variability at the same rate as the sample population. An idealized population is one in which there is no mutation or selection, there are equal numbers of males and females, mating is random, etc. Obviously it is very unlikely that any natural population will meet all criteria for an idealized population.

Breeding structure of a population can profoundly affect the rate at which genetic variability is lost. However, we can determine the effective breeding size (N_e) for breeding structures and obtain the rate of inbreeding (ΔF) as

$$\Delta F = 1/2N_e$$

so the consequences of breeding structure can be related to the loss of variation.

Many breeding structure variations can influence the effective population size. Four seem likely to operate in a salmon hatchery population: (1) numbers of males and females in the breeding population; (2) unequal numbers in successive generations; (3) nonrandom distribution of offspring among families; and (4) overlapping generations. These are discussed in greater detail in Appendix A.

Any of these variations in breeding structure may have a marked effect on N_e. Although it may be impossible to control or even to measure variation in family size it is important to keep in mind the relationship to effective population size. Breeding plans that would aggravate or increase the variation of family size should be avoided. The effect of overlapping populations is to increase the effective population number, in that individuals mating in different years contribute to greater diversity. For example, it would take a larger number of pink salmon each year to maintain $N_e = 400$ than it would sockeye salmon.

The factor having the greatest potential effect in the hatchery and over which we have most control is sex ratio. As the formula indicates (Appendix A) the effective population size is affected most by the numbers of the least frequent sex. It is important to consider this in the breeding plan. In salmon, because a male can be used to fertilize the eggs of a large number of females, there is a temptation to do so. This temptation should be moderated by the necessity to maintain an effective population size which will assure that adequate genetic variation is maintained in the population. A minimum effective population (N_e) of 400 should be maintained. At this size the rate of inbreeding will be 0.125 percent per generation which should not have a significant effect on the long term fitness of the population.

In some cases, for example with chinook and steelhead, small population size may be unavoidable. In such cases a plan should be developed to offset the effects of small population size by infusion of genes from a source outside the hatchery population, such as the original donor source. Help in designing these breeding plans can be obtained from the Principal Geneticist, FRED Division, Alaska Department of Fish and Game.

While developing hatchery stocks from wild donor sources it is important that the genetic variability in the donor stock be protected. Cropping of the early or late run segments of a donor stock can change the timing of that run, which will reduce genetic variability of the population and may be detrimental to the stock's prospects for long term survival. To prevent such selection, sliding egg take scales for donor stock transplants should allocate no more than 90% of any segment of a run for broodstock.

RESEARCH

The necessity for much of this policy arises from our ignorance of the genetics of wild salmon populations and the effects of their domestication in hatcheries. The policy is based more on extrapolation from other disciplines such as agriculture than from first-hand knowledge of our resource. As a result, the policy is a somewhat conservative interpretation of these data in order to assure the long-term viability of salmon populations. The Committee has identified several areas in which specific knowledge would clarify this policy and contribute to the effectiveness of salmon enhancement. The Committee encourages cooperative research efforts among the university, state, federal and private sectors directed toward the general areas listed below.

1. Development of performance profiles of hatchery stocks and potential for genetic improvement. Information about stocks kept in culture will be useful in several ways. If taken in a standard manner, the data will be useful in determining the extent of variability in the species and will aid in the choice of stock to be used for outplanting or transplanting. The information will also be helpful in maximizing the production of a particular facility.

2. Potential for genetic improvement of cultured stocks. A sequel to the cataloging of the variability within and among stocks will be to experimentally assess the potential for genetic improvement by selective breeding. To do this, it is necessary to determine the heritabilities for traits of interest, that is the part of the phenotypic variability present in a population which results from genetic (heritable) causes as opposed to environmental causes. Traits such as size of adults, age of return and various timing parameters are particularly interesting to industry.

Application of artificial selection is responsible for the enormous advances that have been made in agriculture; the potential also exists in aquaculture.

3. Assessment of the effect of introgression of genes from hatchery fish into wild populations. To examine this effect, one must first have an estimate of the rate of straying and the factors that influence straying. Such factors might include transplant distance, run strength, source of the hatchery stock and year-to-year environmental differences. By using a genetically marked stock, one can monitor the flow of "hatchery genes" into other populations. Because the effect of such introgression may develop over time, it is necessary that such an experiment be conducted over several generations. For this kind of study, it may be necessary to develop a means for marking fish cultured at production levels.

   The second part of this problem is to establish the impact of introgression. A range of potential interactions is possible ranging from introgression between two unrelated stocks to the introgression of fish subject to the selective pressures of a hatchery back into the wild stock from which they were derived. Research to examine these effects could best be done in an experimental hatchery where hybrid stocks could be produced and all releases marked. Port sampling and stream walking would be necessary to evaluate survival, straying and other phenotypic effects.

4. The effects of inbreeding and maintenance of inbred lines. Accompanying the artificial propagation of a species is the potential for inbreeding, loss of genetic variability and increased homozygosity. Information pertinent to the extent of inbreeding depression that results from various levels of inbreeding is necessary in determining adequate effective population sizes. This is especially important for species

for which a large effective population size is difficult to maintain. In addition, this information would permit a judgement on the efficacy of enhancing very small remnant populations. This work could be done both by performing crosses designed to accomplish some level of inbreeding, and by the maintenance of small randomly breeding populations. In both cases, it is important to keep careful controls.

APPENDIX A

Appendix A

The relationship of breeding structure, effective population size, and rate of inbreeding.

Breeding structure can profoundly affect effective breeding size (N_e) of a population. We can, at least in theory, determine the effective breeding size for many breeding structures and obtain the rate of inbreeding (ΔF) as

$$\Delta F = 1/2N_e$$

directly relating variation in breeding structure to loss of genetic variation.[1]

The following demonstrates the consequence of some breeding structures to effective population size.

Number of males and females: Unequal numbers of males and females in the breeding population reduce effective population size. Sex ratio is related to effective population number (N_e) as

$$N_e = 4N_m N_f/(N_m + N_f)$$

where N_m and N_f refer to the total number of males and females respectively. The effective population size is strongly influenced by the number of the least frequent sex.

Unequal numbers in successive generations: If the numbers of breeding individuals is not constant in successive generations the mean effective number is the harmonic mean of the number in

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[1] See D.S. Falconer. 1981. Introduction to Quantitative Genetics. Longman Inc., New York.

each generation. Over generations the effective number is approximately,

$$1/N_e = 1/t(1/N_1 + 1/N_2 + 1/N_3 + \ldots\ldots 1/N_t).$$

The generation that has the smallest number will have the largest effect.

Nonrandom distribution of offspring among families: When there is large variation in family size the next generation is made up of the progeny of a smaller than expected number of parents. This can be related to loss of genetic variation through effective population number as

$$N_e = 4N/(V_k + 2)$$

where V_k refers to the variance in family size. When variation of family size V_k is equal to 2, then $N_e = N$. When the number of males and females are unequal, the variance of family size may be unequal in the two sexes and

$$N_e = 8N/(V_{km} + V_{kf} + 4)$$

where V_{km} and V_{kf} are the variance of family size for males and females respectively.

Overlapping generations: In species other than pink salmon generations are not discrete, they are overlapping. When generations overlap the effective population size is

$$N_e = 4N_cL/(V_{km} + 2)$$

where L is the generation time and N_c is the number of individuals born in a year, that is the cohort size. The cohort size N_c is related to the total number (N_t) by $N_c = N_t/E$ and E is the mean age at death. As before V_{km} is the variation of family size.

The effect of unequal sex ratio and unequal numbers in successive generations on population size can be easily estimated. On the other hand it will be difficult or perhaps impossible to estimate the variance of family size. Nevertheless, we should keep in mind the relationships of family size and overlapping generations. Overlapping generations will in general increase the effective population number in that individuals mating in different years contribute to greater diversity. Variance of family size can radically reduce effective population size. Procedures that contribute to variance of family size or separation of year classes should be avoided.

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME
OFFICE OF THE COMMISSIONER

WILLIAM A. EGAN, GOVERNOR

SUPPORT BUILDING
JUNEAU 99801

DEPARTMENT POLICY

STATEMENT OF POLICY ON PERMITTING NONPROFIT SALMON HATCHERIES IN ALASKA

Approved by: James W. Brooks
James W. Brooks, Commissioner

Date: October 3, 1974

STATEMENT OF POLICY ON PERMITTING NONPROFIT SALMON HATCHERIES IN ALASKA

References to Statutory Authority

ALASKA STATUTES:

1. AS 16.10.400-470--Authorizing the operation of private nonprofit salmon hatcheries.
2. AS 10.20--Nonprofit Corporations.

THE NEED FOR POLICY--The way in which privately owned salmon hatcheries develop in Alaska is of significant importance to the managers of the state's common property fishery resources. Spawners or eggs must be obtained from the public's natural resources to stock the private hatcheries; the salmon fry produced in the hatchery will be released from the hatchery operators control into the natural waters of the state to grow, migrate, and mix with wild stocks in a natural manner; and at some designated point near the hatchery site the returning adult salmon surviving the oceanic elements and the traditional fishery will again become the private property of the hatchery owner.

The questions of where the private hatcheries are to be located, which species are to be produced, and how and by whom the returning adults are to be harvested are the central issues of concern to the Alaska Department of Fish and Game. For each proposed hatchery decisions must be made, for example, on (1) where the hatchery should be located so that the management of the state's naturally produced salmon will not become drastically complicated or even impossible because of mixing of wild and hatchery fish; (2) how many spawning fish may be taken from perhaps an already depressed run to stock a private hatchery; (3) whether or not the public's best interests would be served by a private hatchery or public enhancement project at the proposed site; (4) whether or not the private hatchery will preempt from the public the recreational-use fishery potentials near the hatchery site; and (5) how the harvest of the returning run of adult fish--likely mixed with wild stocks--can be best managed.

Policies have been developed to serve as guidelines for determining present and future decisions on how privately owned salmon hatcheries can operate to best serve the interests of the people of Alaska.

These policies will aid in defining which course of action the department should select from a choice of several alternative and perhaps less desirable courses of action. They are to reinforce rather than diminish the need for the managers to use their keenest ingenuity and skill in formulating the numerous complex decisions that must be made in each private hatchery situation. The Department recognizes that the policies must be responsive to a given set of conditions. As conditions change and as hatcheries evolve in Alaska and as they are evaluated, the policies will also change.

Two sets of "statements of policy" are expressed below:

1. The first set deals with the determinations that will be made by the commissioner of ADF&G in judging whether or not a permit for a private salmon hatchery should be granted to an applicant, and

2. the second set deals more with the operational aspect of private salmon hatcheries.

STATEMENTS OF POLICY FOR GRANTING PERMITS--It is the policy of the State of Alaska to foster the private ownership of salmon hatcheries by qualified nonprofit corporations when the following qualifying considerations are satisfied:

1. A determination by the Commissioner of the Alaska Department of Fish and Game that the stream at the proposed hatchery site is either depleted of salmon or is a non-significant producer of salmon and that the stream is unlikely to be restored or enhanced to levels supporting an adequate harvest in a reasonable time by either natural processes or by rehabilitation measures that may be taken by the state.

    (a) The basis for declaring a stream "depleted" will be the determination that either the stream has been adversely altered to destroy its production potential or that, for whatever reason, the escapement history of the salmon spawning runs in the stream indicated a significantly reduced and consistently low level of production.

    (b) The basis for declaring a stream a "non-significant producer" will be the determination that the stream's natural productivity of salmon--even at its maximum--is very low because of its physical limitations, e.g. because very limited spawning area is available. One of the major factors that will be considered in permitting a private nonprofit salmon hatchery on a stream declared a "non-significant producer" will be a judgement as to whether or not substantial increases in salmon production are likely to be achieved by a hatchery. Included in this judgement will be consideration of the quality and quantity of water available and whether or not the stream has an ample egg source for stocking the hatchery.

2. A determination by the commissioner that the nonprofit corporation is both technically and financially qualified and capable of managing a hatchery. That is, a corporation that has been judged as qualified by the Commissioner is one that demonstrates that it has technical advisors with a knowledge of contemporary salmon husbandry practices to assure that seed-stock acquired from the State will not be wasted and is one that is financially capable of paying for necessary monitoring, inspections, and advisory services needed.

3. A determination by the Commissioner that the management of naturally occurring wild stocks will not be unduly hampered by locating the hatchery at the proposed site. If complexities arise in managing mixed stocks, including both hatchery fish and wild fish, it will be State policy to manage the collective resource in a manner that favors protection of the wild stocks.

4. The Commissioner's assurance that the applicant's plans indicate that operation of the hatchery will be consistent with the State's policies on fish genetics and fish disease control.

The Alaska Department of Fish and Game will restrict its hatchery permit procedures to cover only its own responsibilities as the state's fishery management agency. Thus, an ADF&G permit to construct and operate a private nonprofit salmon hatchery will not represent approvals, permits, or licenses that a corporation may be required to obtain from other state and federal and local agencies concerned with matters of real estate, water use, taxation, structures in navigable waters, and environmental protection.

As a provisional policy, the state will use the date-of-receipt of the application with the $100 filing fee as a means for recognizing a proprietory claim to a hatchery site on public lands.

It will be a policy of the department to process only one permit at a time for any private non-profit corporation and to require that the first hatchery show satisfactory progress prior to issuing a permit to construct and operate a second hatchery at another site.

STATEMENTS OF POLICY FOR OPERATION OF PRIVATE SALMON HATCHERIES--

These policy statements apply to the manner in which private hatcheries should operate so that the public interests will be protected. Many of these statements amplify or supplement statements expressed in the Alaska Statutes.

1. Transplantation of Eggs--The department shall closely administer the taking and transplantation of eggs to be used in Alaska salmon hatcheries. Transplantation of eggs is one of the major overriding concerns of the department because this activity can disseminate disease in epidemic proportions and adversely affect important genetic characteristics of both propagated and wild races of fish. The role of fish disease in natural and wild populations is for the most part little understood and remains as one of the major areas of economic risk in management of hatcheries and fish rearing facilities.

Genetic manipulation of fish stocks through inadvertent management practices and transplants of stocks can disturb the heritable characteristics and thereby materially diminish the homing instinct of major portions of fish runs and affect the timing of egg development and hatching, smolt outmigration, and returns of adults. Transplantation of eggs from one stream to another is potentially one of the major biological risks in Alaska's salmon hatchery practices.

The department will not authorize the importation and introduction of salmon eggs from sources outside the State of Alaska for either public or private hatcheries. During the initial development of private hatcheries in Alaska, the department will be especially cautious about approving transplantation of surplus eggs from one private hatchery to another.

The Department of Fish and Game will not assume responsibility for egg mortalities that may occur during the collection, transportation, and after the eggs are received at the hatchery.

2. <u>Ownership of Hatchery Reared Salmon</u>--Salmon reared by private non-profit hatcheries are declared to be a common property Alaskan natural resource from the time they are released into the natural waters of the state until the time that they segregate from naturally occurring stocks at the specific location designated in this permit by the department. After resumption of control of returning fish by the hatchery, the highest priority use of the mature fish will be to provide hatchery brood stock requirements, and if applicable, to provide the natural spawning requirements of the hatchery water source. These requirements must be met before surplus fish or eggs can be sold or otherwise disposed of by the hatchery. Hatchery fish held under positive control within a closed system are declared to be pr[illegible] of the owners of the hatchery.

3. [illegible] Fingerling or Smolt from State Hatcheries--The state will [illegible]hase of fingerling or smolt stock [illegible]e salmon hatchery [illegible]hen such stocks are surplus t[illegible] needs. Current [illegible]g and coho salmon stock by Ala[illegible] hatchery and rehab[illegible] program are so great that sales [illegible]gs and smolts in quantities sufficient for commercial operations [illegible] not be available in the forseeable future. The cost of the fish to the purchaser will be determined on a basis of either the pro rata cost of the state's total hatchery operation or on a highest bid arrangement when competitive bidding is expected.

4. <u>Management of Common Property Fishery</u>--By granting a permit for a private hatchery, the department recognizes its obligation to regulate the fishery to achieve escapements to the private nonprofit salmon hatcheries. It will be the policy of ADF&G to manage the commercial and sports fisheries to return adult fish to the hatchery site in the same manner as it regulates fisheries to obtain a return of spawners to natural streams. While the department will not institute any irregular restrictions on the traditional

fishery, it will strive for an escapement of spawners sufficient for stocking the hatchery and for obtaining an optimum number of natural spawners to the hatchery water source stream.

5. <u>Use of Natural Lakes by Private Hatcheries</u>--The department will exercise particular discretionary and cautious judgement before granting the use of natural lakes to private corporations. Among other things, the department must consider to what extent the permit may deny access of the lake to sport fishermen or to other public uses. As a provisional policy, the department will not permit natural lakes of greater size than <u>10 surface acres</u> to be used solely for rearing of fish by private fish farming or by private nonprofit salmon hatcheries.

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Department of Fish and Game
Division of F.R.E.D.

STATEMENT OF POLICY ON CONTROL OF FISH DISEASE

Disease is an important limiting factor in the success of all operations dealing with animal populations. In populations of aquatic animals, diseases may be caused by pathogenic microorganisms, the effects of toxic materials, or general environmental deterioration. It is known that subtle physical changes in aquatic environments may result in stress and lead to the impairment of fish health. However, the role of disease in the dynamics of wild fish populations is for the most part little understood. The health of these populations must not be jeopardized by enhancement and rehabilitation efforts.

Statements of Policy

1. Protection of Wild Stocks - Wild stocks of fish and shellfish are one of the most valuable of all Alaskan resources. The health of these populations is an important consideration in disease control efforts and the determination of the status of disease in these populations is a research objective. F.R.E.D. Division's Fish Pathology Section shall monitor and guard against any hatchery practices, effluents, or stocks which pose a threat to the health of wild fish populations.

2. Rearing, Movement and Release of Infected Fish - The rearing, movement or release of infected fish shall be avoided. Apparent disease problems must be treated and controlled prior to release of fish. Regular reports dealing with fish health, site inspections, and examination of lots before release are necessary to accomplish detection and control of fish diseases. In cases where treatment is either impossible or impractical, the Fish Pathology Section will, on an individual basis, recommend either destruction of the lot or release with limitations on uses and release sites. Movement of disease carriers into watersheds without a previous history of this disease will be prohibited. All proposed egg and fish transports will require prior approval using the transfer request form.

3. Stock Selection - Import of fish or eggs from distant watersheds, whether intrastate or interstate, will be strongly discouraged. The use of native or resident stocks in all enhancement projects will be strongly encouraged to avoid importation of new pathogens. If the use of actual or suspected disease carrier stocks is necessary to maintain the genetic intrgrity of a watershed, the Fish Pathology Section will, if possible, recommend techniques designed to prevent or minimize these potential problems.

4. Hatchery Practices - The Fish Pathology Section will promote the use of hatchery practices designed to prevent disease. Egg disinfection will be required for all transfers between watersheds, regardless of whether or not a hatchery facility is involved. Fish pathology personnel and facility personnel will work closely concerning actions which have significant fish health ramifications.

5. Use of Chemotherapy - The use of vaccines and preventative methods of fish culture are preferable to treatment of epizootics after they occur. For most purposes, chemotherapy will be considered a last resort to be used when cultural and management techniques have failed to prevent disease. Indiscriminant use of any chemotherapy is prohibited. The decision to treat with any non-cleared drugs, on an experimental basis, shall only be with the advice and approval of the Fish Pathology Section.

6. Consistency of Public and Private Aquaculture Disease Policy - Regulations, policies, and hatchery practices related to disease prevention and control shall be consistent for all Public and Private Facilities.

Robert E. Hinman
Bob Hinman, Director
Game Division

Russell J. Clark 9/21/78
Russ Clark, Director
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ATTACHMENT C
Oregon's Wild Fish Management Policy

Oregon's Wild Fish Management Policy
What is it and what does it do ?

November 5, 1990

The revised Wild Fish Management Policy (WFMP) was passed by the Oregon Fish and Wildlife Commission in January, 1990 with the singular purpose to protect the genetic resources of Oregon's native fish species.

To understand what the WFMP is really all about, there must first be some agreement as to what a "wild fish" is. In addition, the term "genetic resources" and why they are important needs to be clarified.

What is a wild fish ?

The words "wild fish" mean different things to different people. The definition used for Oregon's WFMP may not agree with some of these viewpoints. While a clear understanding of our wild fish definition is crucial to comprehending this policy, other definitions when taken out of the WFMP context, may have equal value and utility.

For the purposes of the WFMP, a wild fish must meet two criteria. It must be a species of salmon, trout, whitefish, or sturgeon native to Oregon. Also included are those non-game native fish that have been placed on the state sensitive species list. Secondly, it must be naturally spawned and descended from a population that was present in the same geographical area prior to the year 1800. For example, naturally reproducing populations of brown trout or largemouth bass (both non-native species) are not wild fish. Neither would be naturally produced Umatilla River spring chinook - the historic Umatilla population went extinct at least 50 years ago. Reintroduction efforts currently underway can not restore this lost genetic heritage, the chain of post-1800 generations has been broken.

An important aspect of our definition is that we assume unique genetic resources exist for each population of wild fish. This is a conservative approach. It is based upon the rationale that if one assumes there are differences between populations, the genetic resources of a particular species are not compromised if this assumption is proven wrong by future scientific evidence.

A riskier approach would be to assume our present level of genetic understanding is adequate to judge that important differences do not exist between certain populations or that hatchery fish have "swamped out" unique features of certain wild populations. Either way new management activities (hatchery programs or fishery harvest) based upon such assessments would likely follow. However, if the original genetic assessment under this approach had been wrong, it is likely the option of recovering and maintaining these population differences would be lost. One of the main objectives of the WFMP was to avoid the possibility of making this type of error. Therefore, given the lack of knowledge surrounding the genetic characteristics of our native fish we determined the conservative approach embodied in the WFMP was the most responsible path to follow.

What are "genetic resources" ?

The construction and operating instruction for every plant or animal is written in the language of DNA and organized in information packages called genes. Like books in a large library, each gene corresponds with instructions for a specific aspect of a fish's structure, function, or behavior. However, any two fish of the same species rarely have the identical instructions for every gene.

Within a given population the existence of variation (i.e., differences in size, shape, behavior, survival...etc.) due to slight differences in specific genes is not uncommon. In addition, when populations of the same species are compared it is not unusual to find larger scale population patterns as to where certain variants of specific genes are found. In other words, genetic variation occurs at two levels: 1) between individuals of a single population, and 2) between populations of an entire species. This two-level genetic variation we define as the "genetic resource" of a species.

Why is protection of genetic resources important ?

The protection of genetic resources is an important issue to fishery management. First, for fish populations to maximize production potential they must retain genetic characteristics which are conducive to high survival in the specific ecological communities and habitats they occupy. Since these habitats vary throughout the range of a species, it is reasonable to assume that genetic characteristics also vary in a corresponding manner. To disrupt this type of variation may result in populations that are less adapted to survive in their native habitats and as a consequence experience a decline in their production (fewer fish).

Second, habitat and ecological communities are not static. Whether natural or human-caused, changes occur. To give a population (and ultimately a species) the best chance for surviving these changes it must retain the capacity to make the appropriate genetic response. In most cases this response consists of a corresponding genetic change. A population that contains a large supply of genetic variation among individuals is, in general, best prepared for making such adaptive changes.

In summary, the preservation of sustainable fish production is contingent upon maintaining populations that are adapted to their local habitats, yet flexible enough to respond to future changes in these habitats. The protection of genetic resources facilitates the mechanism by which this adaptive yet flexible capacity is maintained.

Summary of the Wild Fish Management Policy (WFMP)

Why do we have it ?

The purpose of the WFMP is to protect the genetic resources of wild fish (OAR 635-07-525). However, the other intent of this short section is to limit the management scope of the WFMP. By intentional omission, the WFMP does not classify waters of the state as to where hatchery fish can or can not be planted. Nor does the WFMP require that populations of wild fish be managed to maximize the productive capacity of natural habitat. Fishery management issues that fall outside of protecting the genetic resources of wild fish are not addressed by the WFMP. For example, a wild steelhead population that has been depressed from a run size of 5,000 to a stable level 500 fish due to dam mortalities, over-fishing and adverse interactions with hatchery fish might still be consistent with the specific standards of the WFMP and therefore be acceptable from the genetic standpoint. However, such a depressed population would unlikely meet natural production objectives and corrective actions would be taken. The WFMP provides the genetic foundation upon which desired natural production objectives set in basin plans can be built.

What does it direct us to do ?

The general policy statement of the WFMP is contained in OAR 635-07-526. First, it states that for wild fish, protection of genetic resources is job number one. As such it takes management priority over all other economic, commercial, recreational, and aesthetic benefits. However, it also states that sustaining these benefits is the reason for protecting genetic resources. Second, it directs that all populations of wild fish be managed to meet specific conditions spelled out in subsequent portions of the policy unless withdrawn from consideration by direct action of the Commission. Third, it directs the Department to not take a sudden, "meat cleaver" approach in implementing this policy.

It recognizes that the process of bringing all wild populations into compliance with the WFMP standard may take time, however, incremental progress towards this long-term goal is expected.

What is the WFMP standard ?

The operating principles section of this policy (635-07-527) describes in detail the standard that is desired to be met for all wild populations. While a long section, the standard can be generally stated as follows. For a wild population to be consistent with WFMP it must have no fewer than 300 spawners (with some exceptions). In addition, if hatchery fish exist and spawn naturally within the geographical area where a wild population is found a limit is placed on their relative numbers. For most situations, this limit is set so that during the time period wild fish are spawning, hatchery fish may comprise no more than 10% of the total spawning population. However, in those circumstances where the hatchery fish are from a broodstock that is genetically similar to the wild population the limit is raised to 50%.

A more detailed description of the WFMP standard begins with the first paragraph of 635-07-527. This paragraph stresses that there is uncertainty with respect to the standard developed for the WFMP. The criteria used to define the WFMP standard were based upon our best judgement as to what would be necessary to protect the genetic resources of wild fish. A conscious effort was made to take these criteria measurable in order to avoid the ambiguity and difficulty of such phrases as "., to the extent possible" or "..having a minimum impact". However, the danger of providing a measurable standard is that future evidence may suggest that it is scientifically incorrect. Therefore, as new and better information becomes available the WFMP will be revised as appropriate.

Operating principle number 1, relating to the interbreeding of hatchery fish with wild fish, is the most complex of the six operating principles that define the WFMP standard. Under this principle, several options are given concerning the use of hatchery fish. Hatchery fish can either be removed entirely (option a), manipulated such that they will not reproduce (option b) or controlled in some other way such that their assumed genetic impact on the wild population will not be significant (options c and d).

Option (c) consists of using genetically similar hatchery fish in controlled numbers such that they will not outnumber wild fish on the spawning grounds (i.e., hatchery fish comprise less than 50% of the total spawning population). The 50% limitation is specified because it is unknown if a hatchery can spawn and rear fish from wild broodstock without some genetic change occurring either immediately or in successive generations. Therefore, this limitation is intended to offer some protection should future analyses show that our guidelines for development of hatchery stocks that are genetically similar to specific wild populations do not work.

The concept behind the type of hatchery fish described under option (d) is that they spawn at different locations or times than do wild fish. The objective of this strategy is to reproductively isolate hatchery fish from wild fish. Given this reproductive isolation, it is acceptable if these fish are genetically different from the wild population. For example, if coho salmon released into a particular river all return to the hatchery site as adult spawners, then they will not be able to interbreed with wild fish. Isolation may also occur if the hatchery fish spawn at a much earlier time than do their wild counterparts. The critical issue under option (d) is to prevent hatchery x wild matings in the natural environment.

Finally, a further limitation with respect to hatchery fish is presented in paragraph (e). Particularly for anadromous species, hatchery fish often stray to river systems adjacent to those where they are planted. A high level of straying can seriously impact the genetics of wild populations. In addition, it is not realistic to assume that option (d) hatchery fish will be 100% isolated from wild spawners. Most likely, both option (d) hatchery fish and hatchery strays from adjacent rivers will differ genetically from the wild fish. Therefore, they are lumped together and given a maximum limit in paragraph (e) of 10%. This limit applies only to the time period when the wild fish are spawning. For example a wild population having 900 spawners existing in a watershed which also has 900 naturally spawning hatchery fish may be consistent with WFMP under certain conditions. One of these conditions would be if the hatchery fish spawned so early that only 100 were left during the period wild fish were spawning. This would result in relative numbers that would meet the 10% limit (900 wild fish and 100 hatchery fish) and therefore be acceptable.

During the course of developing the WFMP the 10% limit was a topic of considerable debate. However, based upon the comments received from several geneticists and the output from several different genetic modelling exercises, we feel that the 10% limit provides adequate genetic protection in most situations. The policy does allow for this limit to be reduced when hatchery fish differ substantially from the wild fish.

Operating principles 2, 3, and 4 relate to largely the same genetic concern. A population that has been reduced to a small number of breeding individuals tends to lose genetic variation through a random process geneticists call "genetic drift". Mortality, from any source that suddenly drives a population down to these levels is therefore genetically risky. For each of these three operating principles (each relating to different source of mortality) a boundary of 300 breeding individuals was set as the minimum stable population size that is acceptable under the WFMP standard. In addition, if the population is declining, this decline is only acceptable under the WFMP standard if a breeding population of 300 or fewer fish is not expected within the next 5 years.

The fifth operating principle is a description of special situation that requires an exception from the 300 fish criteria described for principles 2, 3, and 4. A small, trout population isolated by a barrier waterfall best exemplifies this special situation. In such a case there is simply not enough habitat to support a spawning population of more than say 150 adults. However, such a population differs from a population that has been suddenly reduced from 2,000 to 150 fish due to human activities. Because genetic differences between naturally small populations are often great, collectively they represent an important genetic resource. Principle 5 was written to make sure such populations are recognized and that the WFMP accepts them in their natural, below 300 condition.

The last operating principle, number 6, addresses management concerns specific to fisheries operating on aggregates of many different populations. It would be disruptive, for example, to place severe harvest restrictions on a coho salmon fishery in order to bring one or two small populations into compliance with the WFMP when they are aggregated with fish from 50 other populations that are healthy and can withstand harvest. This principle then, is a recognition of the fact that for populations which enter aggregate fisheries extra care must be exercised in bringing them into compliance with WFMP so as to minimize adverse social and economic impacts.

Are there exceptions ?

The WFMP has a provision whereby individual populations may be exempted from ever meeting the WFMP standard (OAR 635-07-528). Although it is hoped this option will be used infrequently under certain conditions the Oregon Fish and Wildlife Commission may take such action.

To exempt a population the Commission must find that social and economic considerations offset the biological consequences of losing the genetic resources of the population involved. Before making such a decision however, the Department is required to prepare an analysis of the long-term biological implications should the population in question be granted an exemption. The critical issue will be whether such action might cause a serious depletion of the species within Oregon. This analysis will also be made available to the public for comment, 45 days prior to the meeting date the Commission considers the exemption.

How will the WFMP be implemented ?

The last section of the WFMP (OAR 635-07-529) describes the steps that will be taken to implement this policy. In developing this section one of the primary goals was to make it possible for the public to objectively measure if the Department was making progress towards achieving the overall policy goal of meeting the WFMP standard for all populations. In addition, it was intended that this section provide directions for a deliberate and accountable process in making key decisions, which implementation of this policy will require.

The first paragraph of this section directs the Department to develop a list of populations for all species of wild fish by January 1991. This is an extremely significant step, because the WFMP is designed to work on a population by population basis. These populations will become the units by which the policy is implemented and by which progress will be judged.

In many situations it will be difficult to identify individual populations, because we do not have enough information to discern clear population boundaries. In those cases when we are in doubt if a group of fish is isolated enough to be a population, we will err on the side of being too conservative and call them a population. Once developed, this list of populations will be examined one at a time against the WFMP standard.

In general, paragraphs 2, 3, and 4 of this section describe actions that the Department is directed to take during the interim period prior to achieving full compliance with the WFMP. They recognize that while existing basin and species management plans are being rewritten to be in compliance with the WFMP, the WFMP will take preference. For preparation of new basin plans, direction is given that they include for each species at least one strategy that is consistent with the WFMP standard. Finally, the Department is directed to not stock hatchery fish into wild fish populations not currently being stocked. The only exception being if such action is approved in a basin plan or if the wild population has been exempted from the WFMP.

Paragraph 5 of this last section describes the preparation of a status report which the Department is required to do every two years beginning with December, 1991. This report will have five components.

First, for each population a historical and current status summary will be prepared based upon best available information. Past records of hatchery fish introductions, changes in habitat, and harvest patterns will be the focus of the historical portion. The current status portion will require an estimate of the number of wild spawners for each population. In addition, if hatchery fish occur within the geographical boundaries of the wild population, estimates of the proportion of hatchery fish naturally spawning during the time the wild fish spawn and whether they are genetically similar to the wild fish will be necessary.

The second part of the report will describe the results of comparing each wild population, using the information described above, against the WFMP standard. Out of this comparison will come two lists. A "pass" list of populations which that consistent with the WFMP standard, and a "fail" list of populations which are either not consistent with the standard or for that there is insufficient information to make a reasonable determination of compliance. This process is to be repeated for each biennial report (every two years).

It is envisioned that the number of populations on the fail list will be used as a report card on the progress with which the WFMP is being implemented. The rate at which the size of this list decreases over the next 10 years will provide an accountable and objective basis for measuring our progress in achieving the intent and goal of the WFMP.

An identification and description of problems for each population on the fail list will be presented in the third portion of the report. Again, lack of data may make this assessment difficult, even for populations that are known not to meet the standard. For example, it may be hard to tell if over-harvest or loss of habitat is responsible for depressing a population below the 300 spawner level (recall that a minimum of 300 spawners is needed to pass the WFMP standard). Questions about the potential productive capacity of the existing habitat and spawner-recruit relationships would need to be at least crudely understood to identify the problem that caused the decline.

The next section in the report will describe possible solutions that the Department has developed for each population on the fail list. The intent of these solutions is, that if implemented, they would result in the population eventually being moved from the fail list to the pass list.

An approximate cost for each of these solutions will be included as part this presentation.

At least initially, the "solution" for many populations may be to obtain the data necessary to fill in crucial data gaps required to permit testing the population against the WFMP standard. For other populations, enough information will be available to propose immediate on-the-ground solutions to bring them in compliance with the WFMP standard. For populations that have failed because of having less than 300 spawners, possible solutions might include: 1) habitat restoration, 2) screening of water diversions, 3) improving passage at dams, 4) changing release locations and numbers of hatchery fish to reduce competition and predation, 5) closing of certain areas to fisheries to protect spawners, 6) reducing direct or incidental fishing mortality on juvenile or adult fish.

For other populations which have failed the WFMP standard because hatchery fish are exceeding the natural spawning limit, another range of possible solutions exist. These include: 1) decrease the number hatchery fish that reach the spawning grounds by reducing the number of fish planted or implementing strategies to target increased harvest on hatchery fish, 2) release hatchery fish that are sterile, 3) increase the number of wild spawners through strategies that increase natural production (i.e., habitat restoration) or regulations to reduce fishing mortality, 3) switch to a hatchery broodstock that is genetically similar to the wild population, 4) develop strategies to draw returning adult hatchery fish away from natural spawning areas (e.g., acclimation ponds, changes in time and place of releases, etc.).

Finally, at the end of this report, a list of those strategies that may have significant effect on future management direction, user groups, or funding requests. This list will include a summary of the decision needed in each case and a corresponding assessment of what each of the possible decision outcomes (i.e., accept, reject, or defer) might mean to the resource, the public, and the Department. Where appropriate the Oregon Fish and Wildlife Commission would be asked to take the action necessary to make specific decisions.

The last portion of the WFMP concerns a short paragraph directing the Department to develop a gene conservation policy and associated program to monitor the genetic status of representative populations.

Mark W. Chilcote, ODFW Natural Production Program
November 5, 1990

Wild Fish Management Policy

Purpose of Wild Fish Management Rules

635-07-525 These rules are established to guide the management and conservation of genetic resources of wild fish in Oregon. Although direction with respect to natural production is provided by OAR 635-07-521 through OAR 635-07-524, additional guidance is required to assure that genetic resources of wild fish are protected. **f. & ef. 1-24-90**

General Policies of Wild Fish Management

635-07-526 (1) Protection of genetic resources shall be the priority in the management of wild fish to assure optimum economic, commercial, recreational, and aesthetic benefits for present and future residents of Oregon.

(2) It is the policy of the Department to implement the Wild Fish Management Rules for all populations of wild fish except those populations specifically exempted by the Commission in accordance with OAR 635-07-528.

(3) It is recognized that management of some populations may not currently be fully consistent with these rules. However, it is the Department's long-term goal to bring these populations into compliance, with the exception of populations specifically exempted by the Commission in accordance with OAR 635-07-528. **f. & ef. 1-24-90**

Operating Principles for Wild Fish Management

635-07-527 The Department recognizes that the operating principles developed to implement this policy are associated with varying levels of uncertainty. These principles shall be continuously revised as better information becomes available. In addition to the operating principles of the Natural Production Rules (OAR 635-07-521 through 635-07-524), the following operating principles apply to the management of populations of wild fish.

(1) Interbreeding of hatchery and wild fish: The interbreeding of hatchery fish with wild fish poses risks to conserving and utilizing the genetic resources of wild populations. These risks shall be limited by implementing either strategy (a), (b), (c), or (d) listed below, consistent with the further limitation described in (e) below.

(a) Eliminate the release of hatchery fish.

(b) Release hatchery fish that are sterile and that do not attempt to spawn.

(c) Release hatchery fish that are maintained to be genetically similar to the wild population and limit the number of all naturally spawning hatchery fish to no more than 50% of the total number of naturally spawning hatchery and hatchery fish that are genetically similar to the wild population are:

(A) Use only hatchery fish that originated from the wild population;

(B) Incorporate naturally produced fish in the broodstock in every generation; and

(C) Avoid random and nonrandom genetic change due to failure to maintain a representative sampling of the genes within a population.

(d) Release fish that are demonstrated to be reproductively isolated (spatially or temporally) from the wild population. The Department recognizes that absolute reproductive isolation may not be possible to achieve and therefore these fish shall be included in the limitation of 10% dissimilar fish stated in (e) below.

(e) Except for genetically similar hatchery fish described in (c), hatchery fish that spawn at the same time and place as the wild population, shall comprise no more than 10% of the total number of naturally spawning fish. A more restrictive level may be designated for those situations where the hatchery fish are known to differ substantially from the wild population in their genetic makeup.

(2) Habitat: Degradation of habitat that reduces the potential for fish production or adversely affects fish migration routes poses a risk to conserving and utilizing the genetic resources of wild populations. The Department shall oppose habitat degradation that causes a population to experience a decline in abundance that if continued for an additional 5 years would likely reduce the number of spawners to 300 fish. In addition, the Department shall advocate the restoration of degraded habitat that has depressed a population to a stable level of 300 or fewer spawners.

(3) Competition, predation, and disease: Introductions of fish of the same or different species as those already present may seriously reduce the survival of wild fish through competition for food and space or through predation. Introductions of disease may also deplete a wild population. An extreme level of mortality from these sources poses a risk to conserving and utilizing the genetic resources of wild populations. The Department shall oppose any actions that allow mortality from competition, predation or disease to cause a population to experience a decline in abundance that if continued for an additional 5 years would likely reduce the number of spawners to 300 fish. In addition, where a population has been depressed to a stable level of 300 or fewer spawners, the Department shall support and advocate actions to correct the cause of such population decrease.

(4) Harvest: providing the opportunity for optimum harvest benefits is consistent with wild fish management. However, an extreme level of harvest, or harvest that disproportionately reduces some segment of a population, poses a risk to conserving and utilizing the genetic resources of a wild population. The Department shall oppose harvest strategies that, by themselves, cause a population to experience a decline in abundance that if continued for an additional 5 years would reduce the number of spawners to 300 fish. In addition, the Department shall advocate the termination of harvest strategies that have depressed a population to a stable level of 300 or fewer spawners.

(5) Small populations: It is recognized that even in the absence of changes brought on by human activities, populations of 300 or fewer spawners may exist naturally. Such populations have survived even though random genetic processes, operating over long periods of time, have probably caused a reduction in genetic variation. Often in the process of losing this variation, rare genetic characteristics become established. From an evolutionary

perspective, protection of these small populations is highly desirable because of the unique features they contain. Therefore, these populations shall not be excluded from consideration for wild fish management.

(6) Aggregate stock fishery management: Some fisheries, such as ocean salmon fisheries, target on aggregations of fish belonging to many different populations. In implementing the Wild Fish Management Rules (OAR 535-07-529), the Department shall pursue the most cost effective, least disruptive (in terms of adverse social and economic impacts on those fisheries), and feasible strategy consistent with the policies and operating principles set forth in the rules. To bring individual populations into compliance with wild fish management, priority shall be given to correcting problems as they relate to use of hatchery fish, habitat, competition, predation, and disease before harvest restrictions on any aggregate stock fishery shall be considered. f. & ef. 1-24-90

Wild Fish Management Exemption Procedure

635-07-528 (1) The Commission may decide, at the request of any person, the Department, or on its own initiative, to determine whether a population shall be exempted from wild fish management.

(2) Such exemptions shall be scheduled for consideration through a rule making either at the next meeting at which the Commission adopts or reviews a basin plan for the area where the population is found, or at the next meeting at which the wild fish management progress report, described in OAR 635-07-529(6), shall be presented.

(3) Before scheduling a rule making on a proposed exemption, the Commission shall direct the Department to prepare a written analysis describing the biological significance and long-term implications of losing the genetic resources of the population proposed for exemption. The Department's report shall also assess whether the proposed exemption would cause a serious depletion of the species within Oregon. In addition, the Commission shall request that the proponent of the exemption prepare a written analysis of the social and economic justification for such action.

(4) The analyses described in (3) shall be made available for public review and comment at least 45 days in advance of the rule making on the proposed exemption.

(5) To exempt a population, the Commission shall find that social and economic considerations offset biological consequences, and that such exemption, when considered alone and in light of any other exemptions that have been granted, shall not cause a serious depletion of the species within Oregon. f. & ef. 1-24-90

Implementation of Wild Fish Management Rules

635-07-529 (1) Within one year of the effective date of these rules, the Department shall develop, for approval by the Commission, a provisional statewide list of populations of wild fish. This list shall be made available to the public for review prior to Commission consideration and approval.

(2) It is the intent of the Commission that, to the extent any basin and/or species plan currently adopted plan shall now be governed by these rules. As existing plans are reviewed and new plans are adopted, the Commission intends that they be explicitly brought into conformity with these rules.

(3) Basin plans presented to the Commission after the adoption of the Wild Fish Management Rules shall present at least one alternative strategy per

wild population that is consistent with wild fish management. For those basins with existing hatchery programs, two alternatives consistent with wild fish management shall be presented; one without hatchery supplementation and one with hatchery supplementation.

(4) The Department shall not stock hatchery fish into wild fish populations not currently being stocked, without authorization in a basin plan approved by the Commission or an exemption of the wild population in accordance with OAR 635-07-528.

(5) Progress toward achieving consistency with these Wild Fish Management Rules shall be reported to the Commission during the first six months of each biennium, prior to preparation of the next biennial budget. Beginning in 1991, each biennial report shall include, by species, the following information:

(a) Documentation of the management history of each wild population based on best available information. This shall include the current status of the population and a history of habitat change, harvest, and hatchery introductions;

(b) A list of populations of wild fish not currently managed consistent with the Wild Fish Management Rules;

(c) Identification and description of the problems preventing the Department from achieving consistency with the Wild Fish Management Rules for each of these populations;

(d) A description of the short- and long-term strategies and associated funding necessary to solve these problems; and

(e) A list of Commission actions, as appropriate, necessary to implement strategies identified in (d).

(6) The Department shall develop a gene conservation policy and a program to monitor the genetic status of representative populations. f. & ef. 1-24-90

Definitions

635-07-501 As used in this Division and Division 40:

(18) "Hatchery fish" means a fish spawned and/or reared under artificial conditions regardless of the history of the parent stock.

(23) "Management Plan" means:

(a) A plan which provides the basic framework (goals, policies and objectives) for managing a resource, geographic area, watershed (waterbody) or species adopted by the Fish and Wildlife Commission in public hearing; and

(b) Which may include specific information or alternatives relative to how the goals and policies may be achieved, e.g., techniques and guidance for implementation of the basic plan normally found in operation plans.

(27) "Natural Production" means the maintenance of naturally spawned fishes and their capacity to reproduce and rear in habitats which allow those fishes to fulfill all their necessary life history functions.

(36) "Population" means a group of fish spawning in a particular area at a particular time which do not interbreed to any substantial degree with any other group spawning in a different area or in the same area at a different time.

(43) "Sensitive" means those fishes that have been designated for special consideration pursuant to OAR 635-100-040.

(48) "Stray" means a hatchery fish that spawns naturally in a location different from the location intended when the fish was stocked.

(52) "Wild fish" means any naturally spawned fish belonging to an indigenous population of the following species:

(A) Oncorhynchus clarki, commonly known as cutthroat trout.

(B) Oncorhynchus keta, commonly known as chum salmon.

(C) Oncorhynchus kisutch, commonly known as coho salmon.

(D) Oncorhynchus mykiss, commonly known as steelhead (anadromous form) or Rainbow trout (non-anadromous form).

(E) Oncorhynchus nerka, commonly known as sockeye salmon (anadromous form) or kokanee (non-anadromous form).

(F) Oncorhynchus tshawytscha, commonly known as chinook salmon.

(G) Salvelinus confluentus, commonly known as bull trout.

(H) Prosopium williamsoni, commonly known as mountain whitefish.

(I) Acipenser transmontanus, commonly known as white sturgeon.

(J) Acipenser medirostris, commonly known as green sturgeon.

(K) All fishes that have been designated as sensitive, pursuant to OAR 635-100-040.