

ALASKA LEGISLATURE SPECIAL COMMITTEE/SUBJECT FILE 8672
1837 SCOMM 74: SEN. SPEC. COMM. ON DOMESTIC & INTL. FISH., 1991-92. 54

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 a 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

^{1/} See D.S. Falconer. 1981. Introduction to Quantitative Genetics. Longman Inc., New York.

each generation. Over generations the effective number is approximately,

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

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

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

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.

FRED Reports

Background of the
Genetic Policy of the
Alaska Department of Fish and Game
by
Bob Davis, Principal Geneticist,
and
Bob Burkett, Chief,
Technology and Development

Number 95



Alaska Department of Fish & Game
Division of Fisheries Rehabilitation
Enhancement and Development

Background of the
Genetic Policy of the
Alaska Department of Fish and Game
by
Bob Davis, Principal Geneticist,
and
Bob Burkett, Chief,
Technology and Development

Number 95

Alaska Department of Fish and Game
Division of Fisheries Rehabilitation,
Enhancement and Development

Don W. Collinsworth
Commissioner

Brian J. Allee, Ph.D.
Director

P.O. Box 3-2000
Juneau, AK 99802-2000

March 1989

The Alaska Department of Fish and Game operates all of its public programs and activities free from discrimination on the basis of race, color, national origin, religion, age, sex, or handicap. Because the department receives federal funding, any person who believes he or she has been discriminated against should write to:

O.E.O.
U.S. Department of the Interior
Washington, D.C. 20240

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
INTRODUCTION.....	1
PROBLEM.....	2
GENETIC CONCERNS.....	3
What We Know.....	3
Genetic Variability and Fitness.....	3
What We Think We Know.....	4
SOLUTION.....	6
APPLYING GENETIC POLICY.....	7
Significant Stocks.....	8
Genetic and Geographic Distance.....	9
Multiple Use of Stocks.....	11
CONCLUSION.....	12

INTRODUCTION

The salmon industry of Alaska is dependent on production of salmon from wild populations. In the early 1970s, a system of public and private nonprofit hatcheries was created for the rehabilitation and enhancement of salmon populations. This came about largely because of several years of very low returns of salmon to many areas of Alaska. This depression of wild stocks was coupled with increases in knowledge of incubation and rearing requirements of salmon. However, the importance of the wild stocks of salmon to the state economy was recognized as paramount. It was also understood that the development and operation of a hatchery system could, if not done with care, have a detrimental impact on wild salmon populations. There has never been any intent to replace wild populations with hatchery fish. The intention is to augment wild production and, perhaps, even reduce fishing pressure on wild systems. A provisional genetic policy was developed in 1975 by the Department of Fish and Game (ADF&G) to protect wild stocks from enhancement activities. It has been revised twice (1978 and 1985). The revisions have extended the policy by developing guidelines that provide for the application of genetic principles to the development and management of broodstock for the hatchery system. The revisions also clarify the rationale for the policy guidelines, and reduce ambiguity in the policy. Protection of wild stocks remains the principal objective of the genetic policy.

Our goal is to discuss the genetic policy and the genetic principles on which it is based. We also will discuss some of the problems encountered in trying to implement the policy. Finally, we will review the policy in an attempt to determine if, in its present form, it achieves the objectives for which it was developed.

PROBLEM

Genetic impacts to wild, indigenous fish stocks becomes a possibility when man decides to (a) transport fish from one locale and release them in another, and (b) when man decides to create by artificial means (hatcheries) fish to supplant those produced by nature. It is important to recognize that to conduct these activities does not automatically mean that genetic impact to wild stocks will follow. The attention man gives to preventing impact will determine whether any impact ensues. While not a topic for discussion here, it should be mentioned that the most clearly demonstrable genetic impact to wild salmon has been produced by commercial harvest.

What are the potential genetic hazards to wild fish populations brought by transport associated with enhancement? There are two. The first hazard is with the effects of gene flow between fish stocks. Gene flow occurs naturally between local stocks of the same species, but our concern is that fish released either at a hatchery or off-station may stray and interbreed with local wild stocks. If these stray fish are poorly adapted to the environment, the fitness of the local stocks potentially can be impacted. It is presumed that wild stocks have been adapted by natural selection to their native environment. Interbreeding with hatchery fish or transplanted wild fish, because these have adapted to a different environment, could reduce the fitness of the local stock. Although we are primarily interested in protection of wild fish stocks, the same dangers exist for hatchery broodstocks.

The second area of concern is with maintaining adequate genetic diversity both within and between fish populations. There are two components to the diversity in a species. There is the variation within each stock and also the diversity among stocks.

Both of these components are important to the long-term well-being of the species.

GENETIC CONCERNS

The science of Population Genetics has been developed over the past 70 years. It is true that there is little, if any, direct information on the genetic impacts of salmon enhancement on wild salmon stocks. However, there is a large body of theoretical and experimental work; the experimental work has been based on a wide variety of plants and animals other than fish. We have applied that body of knowledge to the development of the genetic policy.

What We Know

Genetic Variability and Fitness:

Our approach to policy development has been based on principles of population genetics theory. Population genetics deals with diversity, phenotypic diversity but, especially, with that portion of diversity that is caused by differences in genotype among individuals. A great deal of effort in population genetics is expended in determining the amount of genetic variation that exists both within and between natural populations. Genetic variability is the raw material which allows a population to adapt to its environment. Genetic variation, in addition, seems to increase the physiological stability of individuals and populations. In addition to genetic variability, a central factor in salmon population genetics is population structure. Salmon stocks home with remarkable precision to their "home" stream to spawn. Behavioral barriers to gene flow result in a significant degree of genetic diversity among salmon stocks. The amount of diversity is dependent on a number of factors, such as time since

stocks separated and amount of gene flow between stocks. The amount of gene flow may be related to distance between stocks, or other impediments to migration.

Fitness can be defined as the probability that an individual will survive from conception to reproduction. However, we are primarily interested in the average fitness of the population or stock. It is very difficult to measure the total fitness of an individual because of the complexity of the trait. Anything that can increase or decrease the chance of an individual's survival to maturity affects the fitness of that individual and, therefore, the average fitness of the population to which it belongs. Any loss of genetic variation results in a loss of fitness, but any gain in genetic variation may or may not improve fitness.

What We Think We Know

It follows from what we know about population genetics theory that wild stocks must be approximately in genetic equilibrium. Being in genetic equilibrium means that though the population is constantly subject to natural selection tending to increase fitness, the gene frequencies remain relatively stable and fitness does not improve. The reason this is the case is that additive genetic variance (that portion of genetic variance that will respond to selection) will, over time, have been removed from the population by natural selection. (This has been called the "Red Queen" hypothesis after the character in Alice In Wonderland who said it was necessary to run as fast as they could to stay where they were.) Therefore, a wild stock at any particular location is assumed to be close to maximum fitness and, therefore, the stock best adapted for that location.

We assume also that transplanted salmon will not home as accurately to the new location, at least initially, as native salmon. Homing of some transplanted salmon has improved rapidly over the

first few generations at a new location. This lends support to our assumption.

Finally, genetic distance and geographic distance are assumed to be correlated. Although salmon home with a remarkable degree of accuracy, there is some straying. Chances are that they stray into nearby streams with greater regularity than into more distant streams. It is not unreasonable, therefore, to assume that gene flow between neighboring stocks would result in genetic similarity. Having made that assumption, we have to recognize that there will be exceptions to this general rule. Life history characteristics, environmental features, and geological formations can effectively block gene flow between stocks that are geographically close.

Given these assumptions, we might also consider factors that would enter into an objective consideration of any proposed enhancement project. What is the environment to which salmon adapt? We should recognize that the environment of a salmon population is extremely complex. First, their environment encompasses both freshwater and marine habitats. Both environments vary spatially as well as temporally. In addition, it seems clear that salmon populations are characterized by a great deal of plasticity. Most salmon stocks are able to physiologically adapt to a wide variety of environmental conditions. Further, much mortality in salmon populations is due to pure chance or phenotypic difference rather than genetic selection. "Much differential survival and fertility is purely accidental - an animal may survive because it happens to be in the right place at the right time. This is especially true of organisms that produce a great excess of progeny of which only a few survive to maturity" (Crow and Kimura, An Introduction to Population Genetic Theory, 1970. Harper and Row, New York). Many of the assumptions on which we base our policy decisions are tied to the notion that the genetic composition of indigenous wild salmon

determined primarily by selection. The value of these assumptions is not necessarily negated by the understanding that many differences between stocks have arisen by chance, and environment can perpetuate phenotypic differences without the populations undergoing genetic change. Our basic assumptions represent the most conservative approach to policy; however, we must recognize that these unknowns exist.

SOLUTION

The genetic policy is the solution to the problem of development of a salmon enhancement program while protecting wild salmon populations. As stated earlier, the genetic policy was developed in 1975 to protect wild stocks from possible detrimental effects of artificial propagation and management practices. However, since public and private nonprofit hatcheries have come on-line and proven successful, additional guidelines have been added to protect hatchery and enhanced stocks. The policy was reviewed and revised in 1978, and again in 1985. The purpose of the genetic policy is still to protect wild stocks. The following describes pertinent genetic considerations and how these have influenced the development of the genetic policy.

From the beginning of enhancement efforts, there has been a recognized need for controls on the movement of salmon stocks. The Fish Transport Permit (FTP) was developed to provide control of fish transport. In order for anyone to transport, possess, export from the state, or release fish into the waters of the state, they must hold an FTP issued by the Commissioner of the Department of Fish and Game. Each FTP is reviewed and commented on by selected staff of the department.

Control of fish transport is the only method available for limiting gene flow into fish stocks that need to be protected. Indiscriminate movement of stocks can result in decreased genetic diversity among stocks. Development of criteria for the genetic review of FTP applications has been a problem since the permit was established. Specific knowledge of salmon population genetics and the genetic impacts of salmon enhancement on wild stocks is limited. Consequently, the genetic policy is based more on information from agricultural genetics and population genetics of other species than on knowledge of our own salmon resources. The result is a policy containing guidelines that are rather flexible. We have tried to develop nonambiguous criteria for judging fish transport permits. The policy suggests that because our knowledge is limited, we should apply the policy and presumably evaluate the FTPs conservatively. An attempt to act conservatively gives the appearance of being arbitrary and begs the comment that the policy is too ambiguous. Unfortunately, the present level of our knowledge forces us to be somewhat ambiguous in our guidelines. Conservative application of the genetic policy can occur only if we set somewhat arbitrary limits based on what we know about the genetics of populations.

APPLYING GENETIC POLICY

When stocks are moved, wild salmon are subjected to increased danger of genetic impact. Direct genetic impact requires first that gene flow occur from the transplanted stock to the indigenous wild stock and, second, requires that the fitness of the wild stock be reduced. Simple, starch gel electrophoresis of tissue proteins can often detect whether or not gene flow has occurred between two salmon stocks. But to prove genetic impact conclusively, it is necessary to demonstrate that the fitness of the indigenous wild stock has been reduced. Fitness is measured

in terms of production of biomass by the stock, and any change in fitness must be a measure of that change in production ascribable only to gene substitution. Numerous environmental variables, both biotic and abiotic, also influence production by the stock, and so it borders on the impossible to measure any change in fitness (production) due to gene flow. Year-to-year variation in production due to this set of other variables masks any reduction in fitness that could be expected over a period of time. Hence, changes in fitness of salmon stocks due to interbreeding have never been measured. So it follows that direct genetic impact due to interbreeding has never been demonstrated in salmon.

The genetic policy has been developed to provide guidelines that will allow development of a hatchery/enhancement program while minimizing the potential for genetic impacts on wild stocks to an acceptable level. Stock interaction must allow for the long-term retention of natural communities under conditions that provide the potential for continuing evolution.

Significant Stocks

Salmon populations vary in size from intermittent runs, which may be maintained by straying, to runs of hundreds of thousands of fish. It seems reasonable that all salmon population are not of equal importance. The effect of a salmon enhancement project depends to some degree on the relative value of the stock that might be impacted. The concept of significant stocks arose out of such considerations. Early versions of the policy (1975 and 1978) distinguished between introductions into systems with large indigenous stocks and into systems with few or no indigenous fish. The earlier policies made no attempt to set limits on population size but clearly had introduced the concept of significant stocks.

The 1985 review and revision of the genetic policy was initiated because of a need to remove ambiguity and increase consistency in application of the policy. Members of the review committee were unable to define the term, "significant stock," but did develop an approach to the problem. The committee felt that, while the size of the population is important, "significance" must be defined not only by the magnitude of the run, but also in the context of local importance and utilization. The committee suggested as well that "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." At this time, these suggestions have not been implemented.

Genetic and Geographic Distance

The idea that genetic distance and geographic distance are correlated has also been used in developing and applying the genetic policy. We are led to this idea by two facts of salmon biology. Salmon stocks home to their own spawning grounds with some accuracy and adapt to that particular environment. This tends to cause some degree of genetic separation between stocks. However, there must be background levels of straying occurring between local salmon stocks. The fact that salmon species will repopulate barren streams is evidence that salmon stray; however, straying may also lead to reduced fitness of a recipient stock. Background levels of straying occurs between neighboring, thus genetically similar, stocks. We become concerned when stocks that have been transported from distant locales stray because they are not genetically similar to local stocks. The chance that strays from one stock will interbreed with another is dependent on the distance between the two stocks. It would seem to follow that, other things being equal, two stocks that are separated by a short distance will be more alike genetically than

two stocks that are separated by a greater distance. Every stock will have its own sphere of influence, circumscribed by the straying of its members. The influence of each stock will decrease with distance from its home stream.

Changes of location on the globe result in changes in the environment. That is, in general, environment also changes as a function of distance. This, coupled with the fact that natural selection works to adapt a stock to its environment, lends support to the assumption that genetic differences between stocks separated by a great distance are larger than genetic differences between neighboring stocks.

This relationship between genetic similarity and distance leads to two conclusions: First, local stocks transplanted to a site will have less genetic impact on indigenous populations because of their genetic similarity than stocks transplanted from a greater distance; and, second, stocks local to an area are best suited for transplant within the area or for development of a broodstock at a site within the area.

Salmon stocks have a genetic sphere of influence because of their life history characteristics. All stocks interact genetically with those around them. This concept has governed the way the genetic policy has been applied. It seems obvious as well that each hatchery or enhanced population will also have a genetic sphere of influence. The larger the production of the wild stock, hatchery stock, or enhanced stock, the greater its influence will be on surrounding stocks.

The effect of these genetic spheres of influence is that decisions made in the past seem bound to limit options for future projects. Consider what it means when all stocks influence and, in turn, are influenced by those around them. Transplanted stocks will impact the genetic composition of stocks adjacent to

the release site. Because we assume that wild stocks are in approximate equilibrium, we must assume also that any genetic impact caused by a stock adapted to a different environment (a transplanted stock) will result in some loss of fitness to the indigenous wild stock. The reduction may not be critical; it is impossible to know. It is conceivable that the indigenous wild stock will derive some benefit from the introduction of genetic variation. The result would probably depend on the amount of gene flow that occurs. The amount of gene flow would depend, in turn, on ability to manage the enhanced stock so that straying of returns would be minimized. It would also depend on the degree of genetic difference between stocks and the reproductive success of the straying fish. This aspect of salmon population genetics is not understood. This problem reemphasizes the need to apply the genetic policy conservatively.

Transplants will modify to some degree the genetic composition of local stocks. When remote stocks are transplanted to areas with significant wild stocks, the wild stocks in this locale are changed to some degree genetically, and their status must be reconsidered. Future options may have been limited.

Multiple Use of Stocks

It is important to build stock diversity into the hatchery system. Salmon stocks differ in levels of disease resistance, temperature tolerance, acid tolerance, and in response to artificial selection. Stock diversity will tend to buffer the hatchery system against both natural and man-made disasters. Further, the ability to genetically improve hatchery broodstock performance in the future depends on the availability of genetic variability. Such variability would be present in a hatchery system with a variety of diverse broodstocks.

There is an apparent conflict between the need for stock diversity in the hatchery system and the need to start up individual hatcheries as economically as possible. It is more economical in the short run to develop a hatchery broodstock from excess eggs of an existing broodstock than from a wild source. And, it is difficult to place a monetary value on the long-term value of stock diversity. The genetic policy limits to three the number of hatchery broodstocks that can be established from a single donor. It does not limit the number of release sites for terminal harvest. This limit on multiple use of stocks balances the need for short-term economy and the need to establish and maintain genetic diversity. It will limit the spread of a single stock.

CONCLUSION

Can the genetic policy in its present form be applied in a way that will achieve the objectives for which it was developed? The answer is yes. Although there is an inherent risk to wild stocks from the development and operation of a hatchery/enhancement program, this risk can be managed by reducing the genetic impact on wild stocks to an acceptable level. The need is not to avoid all genetic change, but to allow for the long-term retention of natural communities under conditions that would provide for continuing evolution. To achieve this goal, we have to apply the genetic policy conservatively. This means that if we know, for example, that genetic similarity decreases with distance and our decisions are not to be ambiguous, we must set arbitrary limits on distance a stock can be transported. An effective genetic policy must allow for implementing successful enhancement activities while protecting and maintaining healthy wild stocks.

There are only two primary genetic concerns in protecting wild stocks and implementing a successful enhancement program. The first concern is possible genetic impacts due to gene flow into wild or enhanced stocks. The second concern is the loss of genetic variation within or among stocks. We are obviously concerned with both wild and enhanced stocks. However, Alaska's valuable salmon industry is founded on production from wild stocks, and wild stocks are the source of genetic variation for development of enhanced stocks; therefore, our primary concern is wild stocks. Both gene flow and loss of genetic variation can potentially cause the reduction of total fitness in wild stocks and hatchery broodstocks. The genetic policy addresses these problems in its three main topic areas. The topics addressed are Stock Transport, Protection of Wild Stocks, and the Maintenance of Genetic Variance. The genetic policy addresses the genetic concerns adequately. The policy describes the genetic concerns and presents guidelines that protect wild stocks from impacts of enhancement activities, as well as protecting hatchery broodstocks and enhanced stocks from the problems associated with loss of genetic variation.

The only problems with the policy are those of perception. It is our hope that this paper will serve to promote a better understanding of the policy. One important task remains to be accomplished: The Genetic Policy Review Committee (1985) outlined an approach to the problem of defining significant and unique wild stocks. Any designation of stocks as significant or nonsignificant will be arbitrary. However, some means of defining these terms is critical to the successful application of the genetic policy and must be found.

15 Nov 91, 0700

Biological Interactions of Natural and Enhanced Stocks of Salmon in Alaska:
Genetic Considerations

(alphabetically)

F. W. Allendorf
R.J. Everett
A.J. Gharrett
M.K. Glubokovsky
W. Jones
T.P. Quinn
J.E. Seeb
W. Smoker
and
F.M. Utter

Introduction

The central goal of fishery management is to increase and stabilize productivity of fishery resources. We know from experience that rapid expansion of production usually results in the eventual collapse of the fishery (option A in Figure 1). In contrast, a more measured rate of increase can be sustained and, thus, is preferred in the long-term (option B Figure 1). Option A shows the result of having the single goal of maximally increasing production. Option B shows the result of increasing production while also protecting the genetic integrity of wild stocks. It is often difficult to resist the opportunity to maximize production in the immediate future. Nevertheless, history demonstrates that this is an unwise choice for a variety of reasons.

For example, the abundance of coho salmon in the lower Columbia River below the hydroelectric dams was greatly increased by the production of very few hatchery stocks. This enhancement was accompanied by greatly increased fishing pressure that, in combination with straying from hatchery stocks, has resulted in the extinction of wild stocks of coho salmon in the lower Columbia River. In addition, the total US Pacific coast catch of these fish has decreased to approximately one-half million fish in 1990 from a peak of over four million fish in the early 1980's. This has been accompanied by a reduction of nearly 50% in the number of eggs per female since 1945 (Washington, this meeting).

The Columbia River situation with coho and other salmon species has been incorrectly labeled as "meat vs. museums". That is, we can either use the salmon as a resource or lock-them-up to preserve their genetic diversity. This is untrue and dangerous; if we don't protect genetic diversity there won't be any resource to use in the future. A group of biologists at a recent workshop concluded that "sustainable increases in salmon and steelhead productivity in the Columbia River Basin can only be achieved if the genetic resources required for all forms of production, present and future, are maintained in perpetuity"

(Riggs et al. 1991).

The Alaska Department of Fish and Game (ADF&G) Genetic Policy (1985) is based upon the principle that the long-term productivity of Alaska's fisheries resources depends on the genetic integrity of wild stocks. Wild stocks are the foundation of the commercial fishery economy in Alaska. More importantly, wild stocks contain the genetic resources necessary for continued production in an uncertain future.

The Policy is based upon the principle that diversity buffers biological systems against disaster, either natural or human-induced (page 13). The present document discusses the biological basis for maintaining genetic diversity both within and between local populations of salmon in Alaska. We first outline possible interactions between wild and enhanced populations. We next consider the importance of maintaining genetic diversity in enhanced stocks of salmon. Finally, we conclude with a series of recommendations to protect these important resources.

Enhanced and Wild Interactions

Hatchery supplementation of natural production of salmonids has been practiced for well over 100 years. This supplementation has increased the productivity of salmonid fisheries in some instances. However, problems involving long term survival and loss of diversity of wild stocks have arisen as a direct result of these practices. The conflicts are both genetic and non-genetic.

The genetic concerns are derived from the large number of distinct local populations that have arisen from the strong homing instincts of anadromous salmonids and the differential patterns of natural selection among rivers. Reproductive isolation of these populations in their distinct environmental settings has resulted in genetic adaptations to the local environment. As a result of both inadvertent and intentional unnatural selective pressures in the hatchery environment, hatchery stocks often diverge genetically from their wild counterparts.

Some hatchery fish will inevitably stray into wild populations. The genetic outcome of this straying is unpredictable. Hatchery fish that successfully produce progeny when they interbreed with wild fish, may reduce fitness of the locally adapted populations. Such reduction may result from the displacement of locally adapted genes or the disruption of coadapted gene complexes. Hatchery fish that do not successfully produce progeny when they interbreed with wild fish directly reduce the productivity of that wild population, and may - in the extreme - lead to its extirpation. Introgression can only be detected through genetic monitoring.

Hatchery practices may erode the homing precision of the enhanced populations resulting in an increased tendency to stray into wild populations. It is important to emphasize that even a small straying rate from a large hatchery may produce a large number of strays in comparison to local wild stocks. If the number of strays is large enough, it will almost certainly overwhelm the native fish, regardless of any survival differential favoring the wild stock.

Large numbers of cultured fish also have management implications. In the absence of programs that monitor interactions of enhanced and wild fish, large numbers of hatchery strays can mask the decline of wild fish. Consequently, the estimates of escapement and returns-per-spawner made by fisheries managers may be inaccurate. Furthermore, behavioral interactions with hatchery fish may affect the migratory behavior of wild fish; a disproportionate abundance of hatchery fish may increase the likelihood of interception of wild fish near the hatchery.

The objective of hatchery management is to increase and stabilize the total harvest. Unfortunately, hatchery stocks tolerate much higher exploitation rates than wild stocks. As a result, many wild stocks commingling with hatchery fish during harvest may be exploited at intolerably high rates. Such management conflicts should be addressed prior to development of a production facility. Wild salmon may also be intercepted in hatchery cost-recovery fisheries and brood stock collections.

There are a number of additional biological concerns related to hatchery and wild stock interactions. These include increased potential for disease transmission from hatchery to wild stocks, potential of competition for food resources which may be limiting particularly for young fish, and the attraction beyond normal levels of predators.

Hatchery Broodstock Management

The productivity (fitness) of a system of hatcheries and wild stocks depends on variation among populations. It is likely, for instance, that different stocks may feed in different parts of the marine environment or may use an area at different times; a system that relies on a variety of stocks is more likely to take advantage of localized areas of high productivity and food and to avoid density-dependent effects of overpopulating such localized areas.

Similarly, an important component of the productivity of a stock is the phenotypic variability for numerous traits such as size, age, migration and spawning times, emergence times, etc. Most such phenotypic traits have a significant genetic component. For a stock which faces unpredictable environments from generation to generation, genotypic and phenotypic variation in a population increases the likelihood that its members will distribute to different places and times where opportunities for food, growth, and survival may present themselves.

Broodstock management

The importance of genetic variability, both within stocks and between stocks, has implications both for donor stock selection and for the actual management of broodstocks. Donor stocks must be chosen judiciously to optimize their hatchery performance and minimize their effects on local wild stocks. Broodstock management practices in hatcheries can alter the genetic composition of and reduce the genetic variation present in a hatchery stock. The primary causes are inbreeding and selection, whether inadvertent or directed. Inbreeding which results from using too few parents can rapidly reduce genetic variability. Domestication selection, an unavoidable consequence of hatchery production or inadvertent selection of broodstock

(e.g. for size or timing) usually entails some loss of variability. The rate of loss of genetic variation from inbreeding can be reduced by using a large number of spawners and using approximately equal numbers of males and females.

The phenotypic variation in broodstocks should reflect the variation observed in wild populations in order to reduce the effect of inadvertent selection. The broodstock should include an array of individuals that represent the extent of variation normally observed in a population, especially with respect to timing (migration, spawning, smolting, emergence), and size (and thus correlated traits such as fecundity, egg size, age). Even if the practice is inconvenient, hatchery broodstock managers should use spawners from the entire stock. Failure to do so is likely to cause the loss of the valuable variety of traits present in the stock. Particular practices that perhaps should be avoided are selection for run timing (for example, using the earliest returns to ensure adequate egg numbers) and selection against jacks.

It is important that broodstock managers monitor the performance of the broodstock over the generations. Without a recorded history changes will not be apparent. If changes are not apparent and understood, broodstock management practices cannot adapt to changes. At the least, the broodstock manager of a hatchery stock should monitor such fitness related traits as timing of migration and maturation, size and age of spawners, egg size and egg number in spawners.

Recommendations

A. Policy

1. Abide by established genetic policy.

Alaska Department of Fish and Game, with public input, has developed a genetic policy. The policy was written to protect Alaska's valuable salmon resource. Wild stocks are the mainstay of the Alaska fishery economy; hatchery enhancement is meant to supplement but not to replace them. Hatchery programs must be carefully designed to protect wild stocks, and all

aquaculture programs, present and future, should be reviewed for compliance with the State's Genetic Policy.

2. Assume that all local populations are genetically distinct.

until more data available
Unless otherwise indicated, spatially or temporally distinct spawning aggregations should be presumed to be reproductively isolated populations.

3. Use best possible tagging strategies to monitor interactions between hatchery and wild populations and the genetic "health" of wild and enhanced populations.

Marking techniques might include coded-wire tags, otolith marking, genetic marking or other methods appropriate to the species and logistical constraints of the facility. Genetic marking would be especially valuable for monitoring introgression of hatchery stocks with natural populations. Genetic stock identification or other appropriate techniques should be used to facilitate in-season management of mixed-stock harvests.

4. *Minimize gene flow to wild population*
Remote releases of hatchery fish should be conducted in a manner that minimizes potential gene flow to wild populations. *what is risk*

Remote releases have been identified as a source of undesirable gene flow from hatchery populations to wild populations. Best available technology should be used to insure proper imprinting. Juveniles for remote releases should be held for an appropriate amount of time for imprinting at a release site possessing a freshwater source devoid of conspecifics. A remote release site, even if designed for complete mop-up fisheries, should be considered to be a de facto hatchery site (see Genetic Policy for broodstock/hatchery site guidelines).

- recognize utility of remote release as tool
- this presents risks that some geneticists

B. Activities

1. Keep genetic policy current and pertinent to Alaska's resources and industry.
2. Identify genetic population structure to determine what populations are genetically distinct.

Traits examined should include life history, production, and molecular genetic. Populations should be surveyed prior to any aquacultural activity to provide a baseline for subsequent genetic monitoring. The genetic consequences of hatchery production on adjacent populations should be evaluated during phased-in expansion, and production increases should be halted at the first indication of adverse impact. Production strategies should be adjusted to eliminate any such impact.

- #3 #4*
 * 3. Monitor wild and hatchery stocks to determine extent of straying and introgression.

most critical
need to know what happens when hatchery fish mate with wild fish
 Long-term monitoring of genetic traits of adjacent wild populations

should accompany any aquaculture program. Again, production strategies should be adjusted to eliminate any observed straying or introgression.

- #2*
 * 4. Evaluate the homing of remote-released fish to make the practice as safe as possible. *how much straying - what is impact*

genetic monitoring should be considered cost of doing hatchery program.

voluntary or required

hatcheries now monitor for disease - short term risk
genetic monitoring - long term risk

LEGISLATIVE RESEARCH AGENCY
130 Seward Street, Suite 218
Juneau, Alaska 99801-2196
(907) 465-3991
(907) 463-3351 (FAX)

DATE

2/3/92

FAX NUMBER:

4928

TO:

Mary

FROM:

Glenn Gray

Transmission of the following number of pages including this page 3

MESSAGE:

I called Bill Smoker and he reaffirmed
that ~~the committee is still accepting~~
Mr. Smoker is chair of the resolutions
committee of the Alaska Chapter of the
American Fisheries Society. The committee
is still accepting comments on the proposal.

of "A Tongass Treasure: The Cave Resources of Southeast Alaska," by Jim Baichtal, a geologist with the U. S. Forest Service.

Immediately following the meeting, there were tours for interested members at the fish processing facilities of Silver Lining Seafoods, the FRED hatchery at Deer Mountain and the SSRAA hatchery at Beaver Falls.

Chapter Comments on Tongass Forest Management Plan

The Alaska Chapter has sent a letter to the U. S. Forest Service in response to the Forest Service's request for public comment on the Supplement to the Draft Environmental Impact Statement (DEIS) for the Tongass National Forest Land Management Plan (TLMP). The letter was reviewed by the Environmental Concerns Committee and approved by the Executive Committee. The Chapter had previously gone on record supporting regulations requiring 100 foot wide buffer

strips along fish-producing streams in areas of the Tongass that are to be logged. The Supplement to the DEIS does now include those requirements, as mandated by the Tongass Timber Reform Act. In our comments on the Supplement, the Chapter emphasized that such buffers should be considered minimums, and that habitat biologists should be granted wide discretion to extend the width of the buffer as needed to protect particularly sensitive riparian habitats and valuable fish populations. The Chapter recommended the Forest Service reject the Plan Alternative that did not use the most conservative riparian habitat management prescription.

The Chapter also commented on the inadequacy of the DEIS and the Supplement in addressing the impacts of upland uses, such as roading and logging, on spawning populations of salmon, especially pink salmon. The DEIS and Supplement acknowledge "greater risk" to populations in impacted watersheds, but assume no effect on productivity of these fish in comparing alternative forest management strategies.

Proposed Resolution on Yukon River Wild Stock Management Zone

The following draft resolution was identified at the Annual Meeting, and the membership present voted to have it publicized for informational purposes in the next issue [this one] of *Oncorhynchus*. **IT HAS NOT BEEN APPROVED BY THE MEMBERSHIP**; it does not represent an official position of the Chapter. Background material that was provided by the author of the resolution follows the resolution itself.

The Chapter also received a draft of the "United States Proposal for Establishing a Cooperative Yukon River Salmon Wild Stock Restoration Program." This draft was prepared by the U.S. delegates, including members of both Alaska and National agencies, to the Joint Technical Committee considering Yukon River salmon policy with respect to the U.S./Canada Salmon Treaty. The draft proposal provides insight into the current planning process to establish cooperative management policy for the Yukon. This current process anticipates two outcomes: 1) the establishment of a Regional Planning Team for the Yukon (RPT's in Alaska are representative public bodies that plan salmon enhancement and management and which have been given responsibility for designating genetic sanctuaries), and 2) participation in a joint US/Canada planning process in the Yukon River watershed.

While the proposed resolution was not adopted in response to this draft document, the proposed resolution would convey to the membership the Chapter's policy priorities of the plan.

The following material is being presented to inform the membership about the resolution and to solicit comments on the resolution.

Particularly useful would be comments on the scope of the Chapter's recommendation.

The Yukon is home to a unique group of Pacific salmon, subarctic animals adapted to near arctic conditions. They deserve special care. Should, therefore, resource users of the Yukon be denied any enhancement of salmon production beyond the capacity of wild spawning habitat? There is of course widespread current debate of whether artificial enhancement ever can increase production over that supported by wild

spawning habitat, and perhaps that is the core of the proposed resolution's author's concern.

Alaska has a long established mechanism (RPT's) for public participation in the controlled development of salmon enhancement and Alaska has strong genetic and disease policies that are applied in all salmon enhancement projects. Does the Chapter anticipate that this process will be inadequate to the difficult task of protecting the Yukon's stock diversity? Perhaps that anticipation is also at the core of the proposed resolution.

The Chapter in 1988, in a similar resolution supported establishment of genetic sanctuaries (or refuges) in which harvests but not enhancement could occur and this proposed resolution seeks establishment of a large sanctuary in the Yukon. Is the present protection offered by national parks and refuges inadequate? Will the entire Yukon have to be set aside in order to provide adequate protection?

Please send your comments to W. W. Smoker, Resolutions Committee Chair, University of Alaska Fairbanks, Juneau Center for Fisheries and Ocean Sciences, 11120 Glacier Highway, Juneau, AK 99801 (789-4441) (FFWWS@Alaska). To encourage frank discussion the Committee promises to keep confidential the identities of comment authors.

Proposed Resolution

Yukon River Wild Stock Management Zone

WHEREAS, the Yukon River is one of the largest producers of wild chum and chinook salmon in North America; and

WHEREAS, supplemental hatchery production is being considered as a means to increase harvest levels of Yukon River salmon; and

WHEREAS, increased harvest levels have a potential to severely impact the many small wild stocks included in the mixed stock and mixed species fishery; and

WHEREAS, available scientific literature suggests that hatchery produced salmon can stray and interbreed with wild stocks altering the wild gene pool, reducing stock fitness and threatening the survival of wild populations;

BE IT RESOLVED, the American Fisheries Society, Alaska Chapter, urges the governments of Canada, United States and Alaska to manage the Yukon River as a Wild Stock Management Zone and to implement the following resolutions:

1. Rebuilding of depressed wild salmon stocks should be accomplished with proper management of the resources and not

accomplished through increased hatchery production;

2. Management of the mixed stock fisheries should be governed by the least productive stock with regulations set to insure that these small stocks do not become extinct;

3. In no instance should hatcheries be used as a means to increase harvest levels;

4. As a last resort, aquaculture techniques may be necessary if a specific stock would become extinct without direct intervention.

BACKGROUND

(Statement prepared by author of the proposed resolution)

The Yukon River is one of the largest producers of wild "unenhanced" chum and chinook salmon in North America. Nearly all salmon spawning and rearing habitat remain intact. The fishery is mixed stock and mixed species in nature with commercial and subsistence harvest of salmon taking place from its mouth upstream almost 1,400 miles. The 1978-1986 average annual drainage-wide harvest was 185,000 chinook, 1,161,000 summer chum, 442,000 fall chum and 61,000 coho salmon (Alaska Department of Fish and Game, 1986). The demand placed on Yukon River chinook and fall chum salmon exceeds the capacity of wild stocks to satisfy all user groups and, consequently, several stocks have become depressed.

Supplemental hatchery production is seriously being considered by many managers, fishermen and politicians as a quick-fix means of alleviating the ever-growing demand placed upon the Yukon River salmon resource. Proposals include expansion of the Clear Hatchery near Fairbanks (Tanana River), increasing funding for artificially enhanced Canadian stocks through treaty stipulations, and developing small-scale aquaculture 4-H projects throughout U.S. waters. The necessary public involvement process has not been initiated for Yukon River enhancement projects, even though the effects may be substantial.

Available scientific literature suggests hatchery produced salmon can negatively impact wild populations by decreasing genetic diversity, reducing stock fitness and reducing effective population size. Foreign diseases can also be introduced from hatchery salmon. The salmon stocks of the Pacific Northwest should exemplify what happens when hatcheries are used to "mitigate" for declining wild salmon stocks. Some salmon stocks

are currently being considered for listing under the Endangered Species Act largely due to the ineffectiveness and misuse of salmon hatcheries.

Nehlsen et al. (1991) identified the status of Pacific salmon, steelhead and cutthroat stocks in the Pacific Northwest which included 214 naturally spawning depleted stocks, 101 of which were at a high risk of extinction. A review of 18 quantitatively evaluated supplementation projects in the Pacific Northwest, British Columbia, Alaska and New England found that none had rebuilt wild runs to self-sustaining levels (Miller et al. 1990). In a comprehensive review of supplementation programs, Smith et al. (1985) concluded that supplementation should not be initiated in wild fish only streams and that populations in these streams are best enhanced by habitat protection and harvest control.

Supplemental hatchery production will only further complicate mixed stock fisheries management. Many wild stocks are relatively small which make them extremely vulnerable to overharvest in an intensive fishery. Consequently, should mainstream harvest levels increase in response to hatchery production of salmon, then small stocks risk reduction or elimination. The status of many of these stocks have never been assessed. Management of a mixed stock fishery requires protection of the weak stocks.

References

Alaska Department of Fish and Game. 1986. Annual management report, 1986, Yukon Area. Division of Commercial Fisheries, Anchorage, Alaska.

Miller, W.H., T.C. Coley, H.L. Burge and T.T. Kisanuki. 1990. Analysis of salmon and steelhead supplementation: emphasis on unpublished reports and present programs. Part I in Analysis of Salmon and Steelhead Supplementation. Project 88-100, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Nehlsen, W., J.E. Williams and J.A. Lichtowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries 16:2, American Fisheries Society, Bethesda, Maryland.

Smith, E.M., B.A. Miler, J.D. Rodgers and M.A. Buckman. 1985. Outplanting anadromous salmonids - a literature survey. Bonneville Power Administration, Project 85-68.

Oncorhynchus

Fathom Graphics

P.O. Box 1690

Cordova, Alaska 99574

First Class Mail
U.S. Postage
PAID
Permit # 13
Cordova, AK

ONCORHYNCHUS

Oncorhynchus is the quarterly newsletter of the Alaska Chapter of the American Fisheries Society. Some of the material included in this newsletter is reprinted from the Parent Society newsletter, *AFS Diary* and *Western Division*.

Editor

Alan Johnson

P.O. NMPS, Box 15 USCG Base

Kodiak 99612, 407-4951

FGKODAJ@ALASKA.BITNET

Deadline for materials for the Spring issue of Oncorhynchus is March 10.

Production

Conale Taylor

P.O. Box 200445

Anchorage 99500-0445

Phone/Fax 373-3005

22550 A

Shella F. Helgath

Senate Advisory Council

P.O. Box V

JUNEAU AK 99821

1990

International Symposium on Biological Interactions of
Enhanced and Wild Salmonids

June 17-20, 1991

COAST BASTION INN
Nanaimo, B.C., Canada

SYMPOSIUM SECRETARY

Mrs. Ann Thompson
Pacific Biological Station
Nanaimo, B.C. V9R 5K6
Canada

Telephone (604) 756-7260

Hosted by the Biological Sciences Branch,
and the Salmonid Enhancement Program, of the
Department of Fisheries and Oceans, Pacific Region

International Symposium on Biological Interactions of
Enhanced and Wild Salmonids

P R O G R A M

June 16 Arrival in Nanaimo

1700-2100 Registration
Coast Bastion Inn - Foyer

1900-2100 Welcoming Reception (Ballroom) - hosted by the
Biological Sciences Branch (B.S.B.), and the
Salmonid Enhancement Program (S.E.P.)

June 17

0900-0930 Introductions and Opening Remarks,
Dr. John C. Davis, Regional Director, Science,
Institute of Ocean Sciences, Sidney, B.C.,
Canada, and Mr. David Griggs, Director,
Salmonid Enhancement Program, Vancouver, B.C.,
Canada

SESSION ONE - PRODUCTION TRENDS

Chairman - Dr. F. Keith Sandercock, Salmonid
Enhancement Program, Vancouver, B.C., Canada

0930-1015 Khorevin, L.D., F.N. Rukhlov, and
A.P. Shershnev. TINRO Sakhalin Region, USSR.
Abundance dynamics of mixed (natural and
enhanced) origin salmon of Sakhalin-Kurile
area.

1015-1100 Kaeriyama, M. Hokkaido Salmon Hatchery,
Fisheries Agency of Japan, Sapporo, Japan.
Production trends of salmon enhancement in
Japan.

1100-1130 Break

- 1130-1215 Peltz, L., et al. Alaska Department of Fish and Game, Cordova, Alaska, U.S.A. [Presented by D.M. Eggers]. Trends in abundance of hatchery and wild stocks of pink salmon (Oncorhynchus gorbuscha) in Kodiak Island, lower Cook Inlet, and Prince William Sound, Alaska. ✓
- 1215-1330 Lunch
- 1330-1415 Steer, G., et al. Department of Fisheries and Oceans, Vancouver, B.C., Canada. Trends in biological characteristics and survival rates of wild and enhanced salmonids in British Columbia. ✓
- P 14 1415-1500 Hilborn, R., R. Francis, and S. Hare. Fisheries Research Institute, University of Washington, Seattle, Washington, U.S.A. Hatchery and wild fish production on the Columbia River.
- 1500-1530 Break
- 1530-1615 Whelan, K.F., and P. McGinnity. The Salmon Research Agency of Ireland Incorporated, County Mayo, Ireland. A comparative biological and genetic profile of wild and ranched Atlantic salmon (Salmo salar L.) stocks from the Burrishoole system, Co. Mayo, Western Ireland. ✓
- 1615-1700 Karlsson, L., T. Eriksson, and C. Eriksson. Swedish Salmon Research Institute, Älvkarleby, Sweden. Production trends in reared Swedish stocks of Baltic salmon.
- 1845-2100 POSTER SESSION RECEPTION (Ballroom) - hosted by the Oak Bay Vine Group, April Point Lodge, Province of British Columbia, Rhys Davis Ltd., B.C. Packers Ltd., and Canadian Fishing Company.

June 18

SESSION TWO - GENETIC CONCERNS

Chairman - Ms. Ruth Withler, Biological Sciences
Branch, Department of Fisheries and Oceans, Pacific
Biological Station, Nanaimo, B.C., Canada

- P. 17
- 0830-0915 Allendorf, F.W. University of Montana,
Missoula, Montana, U.S.A. Effects of genetic
changes in enhanced stocks on productivity of
wild and enhanced salmonid populations.
- 0915-0945 Crandell, P.A. University Alaska Fairbanks,
Juneau, Alaska, U.S.A. Genetics of domestic
California rainbow trout (Oncorhynchus
mykiss): implications for wild stocks.
- 0945-1015 Chebanov, N.A. TINRO, Kamchatka Region, USSR.
Experimental assessment of genetic aberrations
in hatchery salmon and the possibilities of
their reduction.
- 1015-1045 Break
- 1045-1115 Gharrett, A.J., et al. University of Alaska
Fairbanks, Juneau, Alaska, U.S.A. Use of a
genetic marker to examine genetic interaction
among subpopulations of pink salmon
(Oncorhynchus gorbusha).
- 1115-1145 Zhivotovsky, L.A. National Academy of
Sciences, Moscow, USSR. Population dynamics
of pink salmon.
- 1145-1330 Lunch
- Chairman - Dr. A. J. (Tony) Gharrett,
University of Alaska Fairbanks, Juneau,
Alaska, U.S.A.
- 1330-1400 Skaala, Ø., K.E. Jørstad, and R. Borgstrøm.
Institute of Marine Research, Bergen, Norway.
Genetic impact on wild populations from fish
farming: experiments with genetically tagged
brown trout (Salmo trutta L.).

- 1400-1430 Smoker, W.W., A.J. Gharrett, and M.S. Stekoll. University of Alaska Fairbanks, Juneau, Alaska, U.S.A. Genetic variation in seasonal timing of anadromous migration in a population of pink salmon.
- 1430-1500 Kawamura, H. Makkari Branch of Hokkaido Fish Hatchery, Hokkaido, Japan. Stock enhancement of masu salmon (Oncorhynchus masou) with hatchery-reared fish and difference in timing of smolting between hatchery and wild populations in Hokkaido, Japan.
- 1500-1530 Break
- 1530-1600 Leary, R.F., and F.W. Allendorf. University of Montana, Missoula, Montana, U.S.A. Use of meristic variation to monitor the health of salmonid fish populations.
- 1600-1630 Gritsenko, O.F., and A.A. Kovtun. VNIRO, Moscow, USSR. Interaction between wild and reared parts of chum salmon populations from the Tym' River.
- 1830-2200 **BANQUET** (Ballroom) - Invited speaker: Mr. Ike Baart, Vice-President, Export Sales, British Columbia Packers Ltd., Vancouver, B.C., Canada. Marketing aspects of salmon production.

June 19

SESSION THREE - FACTORS AFFECTING FRESHWATER AND MARINE PRODUCTION

Chairman - Dr. Doug M. Eggers, Director of Research, Commercial Fisheries Division, Alaska Department of Fish and Game, Juneau, Alaska, U.S.A.

- 0900-0945 Kitchell, J.F. Center for Limnology, University of Wisconsin, Madison, Wisconsin, U.S.A. Salmon in the Great Lakes: a compromised miracle.
- 0945-1015 Karpenko, V.I. TINRO, Kamchatka Region, Petropavlovsk, Kamchatka, USSR. The role of early marine life in forming Pacific salmon production.

- 1015-1045 Beamish, R.J., and B.L. Thomson. Biological Sciences Branch, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C., Canada. Survival of hatchery-reared salmon in the Strait of Georgia.
- 1045-1115 Break
- 1115-1145 Wood, C., et al. Biological Sciences Branch, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C., Canada. Testing for ecological interactions between wild and hatchery-reared salmonids as an explanation for declining smolt-to-adult survival in sockeye salmon (Oncorhynchus nerka) populations of Barkley Sound, Vancouver Island.
- 1145-1215 McAllister, C.D., and C.D. Levings. Biological Sciences Branch, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C., Canada. Evidence of habitat limitations for hatchery and wild chinook salmon (Oncorhynchus tshawytscha) in two British Columbia estuaries.
- 1215-1330 Lunch
- Chairman - Dr. Blair Holtby, Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C., Canada
- 1330-1400 Beall, E., and M. Héland. INRA, Unite Ecologie des Poissons, Station d'Hydobiologie, Saint-Pee-sur-Nivelle, France. The influence of introduced coho salmon (Oncorhynchus kisutch) juveniles on the survival, growth, distribution, and production of Atlantic salmon (Salmo salar) fry and parr.
- 1400-1430 Seiler, D., et al. Washington Department of Fisheries, Olympia, Washington, U.S.A. Supplementation of wild coho salmon (Oncorhynchus kisutch) with hatchery-produced fry in Washington coastal streams.

These files
into reporting
the coho
problem

- 1430-1500 Cramer, S.P. S. P. Cramer & Associates, Fisheries Consultants, Corvallis, Oregon, U.S.A. Dynamics of the decline in wild coho (Oncorhynchus kisutch) populations in the lower Columbia River.
- 1500-1530 Break
- 1530-1600 Labelle, M., C.J. Walters, and B.E. Riddell. University of British Columbia, Vancouver, B.C., Canada. [Presented by C. Walters]. Ocean survival and exploitation patterns of hatchery and wild stocks of coho salmon (Oncorhynchus kisutch) from southeast Vancouver Island, British Columbia.
- 1600-1630 Francis, R.C., and R.D. Brodeur. Fisheries Research Institute, University of Washington, Seattle, Washington, U.S.A. Production and management of coho salmon (Oncorhynchus kisutch): a simulation model incorporating environmental variability.
- 1700-2200 TOUR - Choice of tour to Big Qualicum River Project or Robertson Creek Hatchery/Somass River. (Dinner not included in registration.)

June 20

SESSION THREE - (continued)
FACTORS AFFECTING FRESHWATER AND MARINE PRODUCTION

Chairman - Dr. Robert C. Francis, Fisheries Research Institute, University of Washington, Seattle, Washington, U.S.A.

- 0900-0930 Ward, B.R., F.A. Slaney, and A.F. Tautz. Ministry of Fisheries, Province of British Columbia, University of B.C., Vancouver, B.C., Canada. Differential survival and synchronous return from the sea in Keogh River wild and hatchery steelhead (Oncorhynchus mykiss).
- 0930-1000 Leskelä, A., et al. Merenkurkku Fisheries Research Station, Vaada, Finland. Variations in the relative year-class strength and growth of anadromous whitefish (Coregonus lavaretus s. str. L.) in the rivers flowing into the Gulf of Bothnia.

- 1000-1030 Evans, D.O. Ontario Ministry of Natural Resources, Fisheries Branch, Maple, Ontario, Canada. Factors affecting angling yields of wild, self-sustaining, and hatchery-supplemented stocks of lake trout, Salvelinus namaycush, in eastern Canada.
- 1030-1100 Break
- 1100-1130 Hayashizaki, K., and I. Hitoshi. School of Fisheries Science, Kitasako University, Japan. Size decrease of chum salmon, Oncorhynchus keta, in Tohoku districts, Japan.
- 1130-1200 Koenings, J.P., et al. Alaska Department of Fish and Game, Soldotna, Alaska, U.S.A. [Presented by G. Kyle]. Collapsed populations and delayed recovery of zooplankton in response to intense juvenile sockeye salmon (Oncorhynchus nerka) foraging.
- 1200-1330 Lunch

June 20

SESSION FOUR - FISHERIES MANAGEMENT

Chairman - Mr. Paul E. Sprout, Division Manager, South Coast Division, Fisheries Branch, Department of Fisheries and Oceans, Nanaimo, B.C., Canada.

- 1330-1415 Geiger, H.J., et al. Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska, U.S.A. The management of the Alaskan salmon hatchery commercial harvest.
- 1415-1500 Riddell, B.E., P.E. Sprout, and A. Cass. Department of Fisheries and Oceans, Nanaimo, B.C., Canada. Managing wild and enhanced salmonids: a review of three British Columbia fisheries.
- 1500-1530 Coffee

P 117 1530-1615

Lichatowich, J.A., and J.W. Nicholas.
Jamestown Klallam Tribe, Sequim, Washington,
U.S.A. The use of hatcheries in the
management of Oregon's chinook (Oncorhynchus
tschawytscha) and coho (O. kisutch) salmon
stocks: case histories and general
observations.

1615

Chairmen's Concluding Comments

Concluding Remarks - B. E. Riddell, Organizing
Committee Chairman

For 1/1/1991
in concluding remarks
- integration of management
in measures.

Production trends of salmon enhancement in Japan

Masahide Kaeriyama

Hokkaido Salmon Hatchery
Fisheries Agency of Japan
2-2, Nakanoshima, Toyohira-ku
Sapporo 062
Japan

Most Pacific salmon stocks in Japan derive from hatchery production except for some natural spawning populations of masu and kokanee salmon. The abundance of chum and pink salmon increased from 5 and 1.2 million individuals in the 1960s to 50 and 3.8 million individuals in the 1980s, respectively. Success of the enhancement program for chum and pink salmon in Japan has resulted from increases in the return rate and the numbers of juvenile released. With an exponential increase of the population size, however, decrease in size and increase in average age have been observed among adult chum salmon returning to Japan. These phenomena suggest that there has been a density-dependent reduction of growth of individuals within Japanese chum salmon populations. However, there is little evidence that the survival of chum salmon has declined. In addition, fears have been expressed concerning effects of hatchery production on the genetic variability of chum and pink salmon. These fears may be supported by the following observations: (1) reduction in the proportion of effective number of breeding to total number of returning chum salmon, (2) a decrease in late running individuals of chum and odd-year pink salmon, (3) reduction of variation in the timing and duration of maturation of individual fish. Future objectives of the salmon enhancement program are summarized as follows: (1) ecological stock management based on the systematic planned production of salmon populations within their carrying capacity in the North Pacific Ocean, (2) genetic preservation of original populations and genetic stock management, and (3) supply of better quality salmon as food for consumers by increased production programs of sockeye and masu salmon.

Hatchery and wild fish production on the Columbia River

R. Hilborn, R.C. Francis, and S.R. Hare

Fisheries Research Institute, WH-10
University of Washington
Seattle, Washington 98195
U.S.A.

Because of extensive hydroelectric development, the Columbia River has been the site of the most intensive hatchery program for Pacific salmon in North America. In this paper we review the history of hatchery releases on the Columbia, and, to the extent possible, document the production of adult fish from these hatchery releases. The hatchery programs have not been successful at mitigating for the loss of natural runs; returns of adult salmon to the Columbia are far below what they were prior to the development of the hydroelectric system. Many hatcheries have failed to produce adult fish, and constitute a net drain on the system by using natural spawners as an egg source. In addition, comparative studies suggest that wild fish normally show much higher survivals than hatchery fish.

We conclude that the attempt to mitigate for losses on the Columbia River by hatcheries has failed, and suggest that the following actions be taken to make the hatchery program more successful. First, hatchery managers should receive financial incentives for production of adult fish from their facilities, rather than for release of juvenile fish. Second, hatcheries should be required to periodically prove their effectiveness through a licensing hearing, and hatcheries that have failed to make a real contribution to the adult return should be closed.

**Effects of genetic changes in enhanced stocks on productivity
of wild and enhanced salmonid populations**

F.W. Allendorf

University of Montana
Division of Biological Sciences
Missoula, Montana 59812
U.S.A.

Programs designed to increase productivity through artificial enhancement generally increase productivity in the immediate future; however, such activities may affect genetic resources adversely and decrease sustainable productivity over longer periods of time. Genetic changes are expected to occur in enhanced stocks because of genetic drift, inadvertent selection, and purposeful selection. A large body of empirical data indicates that such genetic changes are common in salmonid stocks. Determining the genetic effects of enhancement programs on wild populations is much more difficult. Nevertheless, there is growing evidence that enhancement programs often have affected wild populations by causing the loss of local adaptations and by increasing natural patterns of genetic exchange among subpopulations (i.e., increasing gene flow). The genetic diversity present in wild populations of salmonids is an invaluable and irreplaceable resource.

**Dynamics of the decline in wild coho (Oncorhynchus kisutch)
populations in the lower Columbia River**

S.P. Cramer

S.P. Cramer & Associates
Fisheries Consultants
1140 N.W. Walnut Boulevard
Corvallis, Oregon 97330
U.S.A.

Populations of wild coho salmon spawning in tributaries of the Columbia River below Bonneville Dam (km 235) declined precipitously during 1971-73 and have remained at low levels since. Abundance of coho returning to 15 hatcheries within this lower Columbia area remained stable through these years. Although abundance declined simultaneously in wild populations throughout the sub-basin, data on spawning time, ocean distribution, and fecundity clearly indicate stock differentiation. Time of peak spawning ranges from late October to mid-February. Experiments with brood selection of lower Columbia coho have demonstrated time of migration and time of spawning are highly heritable and correlated. Hatchery stocks now enter the Columbia River and spawn 4-8 weeks earlier than the natal populations from which they were derived. Spawning time of wild coho in the Clackamas River, a tributary, has shifted 2 months later since 1970, apparently in response to selection by high harvest rates in the Columbia River during the historical peak time of river entry. Evidence is presented that selection for time of river entry and time of spawning is continuing.

The sharp decline in abundance of coho during 1971-73 was coincident with a sharp increase in harvest rates in the river and ocean. Harvest simulations demonstrate that present harvest rates will drive wild populations to extinction. Outplanting of poorly adapted hatchery coho probably aggravated the decline of wild populations.

**Managing wild and enhanced salmonids: a review
of three British Columbia fisheries**

B.E. Riddell, P.E. Sprout¹, and A. Cass

Department of Fisheries and Oceans
Biological Sciences Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6
Canada

¹ Department of Fisheries and Oceans
South Coast Division
3225 Stephenson Point Road
Nanaimo, British Columbia V9T 1K3
Canada

Intermingling of salmonids from enhancement programs with wild salmonids complicates the already formidable task of managing Pacific salmon fisheries. In this paper we document catch trends and harvest management issues associated with enhancement in three major salmon fisheries in British Columbia. The enhancement programs include: (1) the Babine Lake sockeye spawning channels developed to increase production to the Skeena River sockeye fishery; (2) Robertson Creek Hatchery, Canada's largest chinook hatchery, developed to increase catch in ocean troll fisheries and which now supports important terminal fisheries in Barkley sound and, (3) the complex of hatcheries developed in the Strait of Georgia to increase the catch of chinook and coho salmon in the Strait. Enhancement has exacerbated mixed-stock and mixed-species problems in salmon management but has also resulted in new or augmented fishing opportunities. However, for enhancement to be integrated with management of wild stocks requires explicit production objectives and harvest management plans. Experiences in managing these fisheries are compared and recommended roles for enhancement are discussed. Further, we suggest that more effort be directed at how harvest management policies can be implemented that provide for a balanced approach in the use of enhancement.

The use of hatcheries in the management of Oregon's chinook
(Oncorhynchus tshawytscha) and coho (O. kisutch)
salmon stocks: case histories and general observations

J.A. Lichatowich and J.W. Nicholas¹

Jamestown Klallam Tribe
305 Old Blyn Highway
Sequim, Washington 98382
U.S.A.

¹ Oregon Department of Fish and Wildlife
850 S.W. 15th Street
Corvallis, Oregon 97333
U.S.A.

Artificial propagation has been a major tool in the management of Oregon's chinook and coho salmon stocks for over 100 years. However, the role of hatcheries in the management of coastal stocks of the two species has differed. Coastal stocks of chinook salmon have been managed primarily for natural production whereas coastal stocks of coho salmon have been managed primarily for hatchery production. An overview and comparison of the two programs is presented. Specific case histories that provide greater understanding of the use of artificial propagation in fisheries management are discussed. The lessons obtained from Oregon's use of artificial propagation over the past century are summarized.

November 14, 1991 Ted Cooney

Ocean Carrying Capacity - Session 1 Review

Five presentations reviewed several different aspects of the issue of carrying capacity as it pertains to salmon production in the north Pacific Ocean. A theoretical food-web model was used to estimate present levels of fry (1.2 billion combined wild and hatchery) feeding demand on naturally occurring zooplankton stocks in Prince William Sound. Estimates of food demand driven by juvenile growth rates of 3 - 5 % body weight per day and adjusted for early ocean fry mortality, suggested minimal impact (< 10%) on total annual zooplankton production. Uncertainties associated with interpreting these model results included questions about the residence time of juveniles in the Sound, and the percentage of the region actually used for feeding purposes. Additional information about relative forage stock abundance in shelf and coastal environments in Lower Cook Inlet and near Kodiak Island was presented to suggest the 'uniqueness' of Prince William Sound as a juvenile salmon foraging habitat. Communication with the 'open' Gulf of Alaska and the depth of the Sound (to 800 meters) interact to host much larger zooplankton stocks than found elsewhere in southcentral Alaska.

Density-dependent growth patterns were described from Japanese hatchery-released chum salmon returning to the Iwate Prefecture (Honshu). Over the past two decades the production of chum salmon in Japan has increased from 5.8 to 50 million adults. During this period, several dramatic changes have been documented. Adult body size and weight have declined, while the mean age of adults has increased slightly. For (ocean?) age 4 (0.3) fish, growth reduction (stunting) determined from scale analyses was most pronounced during the first year of ocean residence. A general decline in the number of eggs per female also accompanied the overall size of adults, as did the condition factor. These measurable changes were attributed to density

dependent growth limitations associated with increasing numbers of hatchery releases.

Density-dependent growth was also described for Bristol Bay sockeye salmon from 1959 - 1991. The extremely small size of returning fish (marine age and sex) in 1990 and 1991 prompted a re-analysis of density-dependent growth accounting for red and chum salmon originating from other areas. The inclusion of fish from outside Bristol Bay did not improve the correlation between numbers of Bristol Bay salmon and mean size in a run. Although sea surface temperatures during winter improved the overall multiple correlation, the small-sized 1990 and 1991 sockeye salmon remained as outliers. It was concluded that the greatest effects of density-dependent growth occur during the last winter/spring of ocean residence in schools of maturing fish near the Alaska Peninsula. No explanation was provided for the anomalous 1990 and 1991 small-sized sockeye salmon.

Historical hatchery practices in Washington and Oregon were discussed to illustrate major mistakes associated with early attempts at large-scale salmon stock rehabilitation programs in the Columbia River. While the intent was meritorious, results were generally disastrous, giving rise to ever increasing problems over time. Coho salmon production declines, blamed on ocean growth conditions, were later attributed to poor freshwater survival and diseases. Precocious returns following external?? freshwater rearing led to greatly reduced reproductive potential. Increased fishing pressure on hatchery stocks eliminated already weakened wild populations. Little or no attention was paid to artificially induced behavioral changes in hatchery stocks including feeding 'niches' and smolting times. These and many other unfortunate results of 'learning by doing' have cast serious doubts on artificial propagation as a mitigation tool. Fortunately, the results of these dubious or otherwise misguided practices are a matter of record. There is no reason that the lessons of Washington and Oregon need to be relearned in Alaska. In this case, 'hindsight' is available in the present and must be

used to prevent the kinds of mistakes that have characterized hatchery and management practices elsewhere.

The session concluded by reviewing some of the broader aspects of the carrying capacity phenomenon in the North Pacific Ocean. A discussion of historical salmonid stock data and oceanographic factors (conditions) demonstrated relationships between forage stock abundance and fish weight, between ocean survival and ocean growth, and between growth conditions and ocean temperature. Since 95% of the growth of salmon occurs in the sea, it is not surprising that variable ocean conditions result in measurable changes in salmon growth and survival. This understanding is still in its infancy, although advances in oceanography and fisheries science are adding new knowledge at an increasing rate. The oceanic environment can no longer be considered a black box.

There is a carrying capacity for ocean. What it is is not known.

Density dependency

Problem w/ smaller size - growth conditions
fecundity
marketing

very small size - ecosystem dynamics
near shore
shelf sea
open ocean

PWS data in litigation.

* when this data forthcoming, convene another workshop on that

- where does density dependent growth occur
- need for quantitative effects of predation + competitors
local predator watch
Are pollock may be major predator (Gulf)
- ~~the~~ open ocean vs. local areas.

PWS - wild stocks not at highest abundance, but

New technologies available - need to use them
satellite, oceanographic buoys, ^{hydro}acoustics

internal scope of open ocean -
long term - limit on No. Pacific production?

other phenomena sea lions and fur seals ↓
monitor other measures of carrying capacity

productivity of ocean not constant, are we headed to natural decline?

inverse relationships - ^{ocean} temp. + wild reproduction

no strong evidence that we have reached carrying capacity
for ocean for salmon, but perhaps have in local areas.

- how small is too small - recent question.

- early & late are target areas.

- when get ^{too} small - might start making pink's mature as 3 yrs
breakdown in age structure could affect future productivity old.

B Bay sockeye, Russians, all pink stocks smaller this year.

too evidence now, but should be cautious about future.

November 14, 1991

Don Amend

Can wild and enhanced coho stocks
co-exist in S.E. Alaska?

Background

The Alaska legislative mandate during the development of statutes and regulations for the Alaska enhancement program was to manage for the natural stocks while enhancing salmon to supplement natural production. The enhancement of coho salmon in S.E. Alaska started in the mid-1970's by the FRED division and the private non-profit operations started in the early 1980's. These programs have now matured and production has stabilized.

The average annual harvest of coho salmon from 1980 through 1988 was 1.71 million. The average harvest of enhanced coho from 1986 through 1990 was 8.1 percent of the total harvest, but the average in the future, based on current production levels, is expected to average about 16 percent.

Coho in S.E. Alaska are harvested primarily by trollers but significant harvest occurs by the drift gillnet and seine fleets as a by-catch during the conduct of traditional fisheries. Although some coho are harvested from Canadian systems, most are produced from S.E. Alaska systems. Because most of the coho harvested in S.E. Alaska are from natural production, it is important to maintain the wild coho stocks.

Enhancement Strategy

The enhancement strategy in S.E. Alaska follows three basic

courses: (1) release from freshwater raceways as smolts into adjacent rivers, (2) release from marine net pens as smolts at remote locations following an imprinting period, and (3) release fed fry into non-anadromous lake systems and the fish immigrate after rearing and smolting in the lake. Typically, broodstock were secured from local wild stocks and the fry reared in hatcheries located on non-anadromous systems which are not near natural producing stocks. Fish released as smolts are typically reared about 18 months in a hatchery, and the fish return after about 18 months at sea. Fish released as fed fry are reared to about a 1 gm size in the hatchery, but they complete the remainder of their life cycle similar to wild coho.

Threats and/or Concerns

There are both intra-species and inter-species concerns. The intra-species concerns include wild stock interactions due to straying or competition and management implications. Inter-species concerns primarily involve predation.

There have been no documented negative impacts of enhanced coho on wild coho in Alaska. Hatcheries in S.E. Alaska are located on non-anadromous systems, therefore, the smolts do not compete with wild stocks in the freshwater phase after being released. Coho imprint well to the site where they are released and there have been no documented straying problems. Consequently, there have been no genetic problems regarding inbreeding at hatchery coho and wild coho. Potential exists for future problems if hatchery stocks become inbred and significant

straying occurs. This should require continued monitoring. Also, research should better define minimum conditions for imprinting for remote release programs. Enhancement practices should continue to follow policies that would minimize inbreeding or increased straying.

The recent past average of 8 percent enhanced coho in the harvest has not been a management problem. Even with production capacity at a maximum, the forecast is to average 16 percent of the harvest. Also, all coho releases include a coded wire tagging program. This allows managers to account for the hatchery contribution to the harvest. Due to the low percentage of enhanced coho in the total harvest, there should be no future management concern. However, the coded wire or marking programs should continue to avoid potential problems of local abundance near hatchery sites.

The inter-species concerns are primarily coho smolts predating on pink fry and to a lesser extent on chum fry. The scientific literature well documents that coho smolts will eat pink fry and in preference to chum fry. In areas where there is a high abundance of coho smolts, the potential exists for the coho to have a significant impact on pink salmon populations. Whether coho are a limiting factor overall to pink salmon abundance is a much broader question which can only be answered by resolving the overall predator-prey relationship among all predators. Because coho abundance cycles coincide when pink abundance appears to argue against a positive correlation of coho limiting pink

abundance. However, this does not resolve the concern of high coho abundance near hatcheries where wild pink fry are migrating.

Several studies in S.E. Alaska have been conducted to answer concerns about high abundance of coho predating on pink fry. The results were inconclusive. Pink fry were on occasion found in the stomach of coho fry, but the magnitude of the problem could not be properly answered. Early life histories of pink fry showed that they typically spend a short time in the inter-estuaries and 90 percent of the pink fry have migrated toward offshore by late May. In order to minimize the impact period, hatchery released coho smolts have been delayed to after June 1st. Although this is not considered to be the optimum release time for coho (mid-May would be better), satisfactory survival rates for coho have occurred. This appears to be a satisfactory compromise in order to reduce the concerns of high abundance of hatchery coho negatively impacting pink populations.

Conclusions and Recommendations

Enhanced coho stocks can co-exist with wild coho stocks as long as current policies and practices are maintained. Coho hatcheries should not be located on anadromous systems or near major coho producing systems. Hatchery practices should be followed to minimize inbreeding and practices which would increase straying should be avoided. The current level of production should not be a management concern but tagging programs should be maintained to resolve concerns of local abundance. Research is needed to better define the conditions for

optimum imprinting and the predator-prey relationship between coho smolts and pink fry needs to be better defined. The coho enhancement program in S.E. Alaska appears to be meeting the original legislative intent of supplementing the harvest of coho salmon but not negatively impacting wild stocks.

Tony Gannett -
N SE - don't use local stocks, concerned @ this.
— make plants in Anhe Bay. — F&G
seems foolish since there are other options.

Jim Seeb objects -

hatching programs - present + future should be reviewed
for compliance w/ state genetic policy.

November 14, 1991

Don Bailey -

**Harvest Management of Mixed Stocks of Enhanced
and Wild Pink and Chum Salmon**

B.C. & other areas.

Ample evidence exists in Pacific Salmon harvest management that harvesting has occurred above their sustainable capacity. Hatchery production in many cases has been a response to low production caused by overharvesting. Evidence also exists that wild stocks can be harvested beyond their sustainable capacity when mixed with the more abundant and more productive enhanced stocks.

Depending on their productivity wild pink and chum stocks may be able to sustain harvest rates of 50 - 70% while enhanced stocks should be able to sustain harvest rates of 85-95%. In British Columbia where enhanced and wild stocks co-exist, exploitation level is based on the lower wild stock productivity and often on the weakest stock. Additional harvest of enhanced stocks is then carried out in terminal harvest areas. This is the procedure used to manage the South Coast of B.C. chum stocks passing through Johnstone Strait.

Data on the productivity of wild stocks is important both annually and during the fishing season in order to adjust harvest to meet fixed escapement goals. In the above example pre-season estimates via tests fisheries and catch sampling for marked enhanced stocks are critical for management to fixed escapement goals. Careful management is especially critical when productivity is low. Tom Royer (pers. comm.) has shown that Gulf of Alaska air temperatures are related to pink productivity. This data would indicate the future pink productivity may be lower. Changes in stream flows from watershed harvesting are also known to seriously reduce freshwater productivity of wild pink and chum stocks. Forest harvesting in Prince William Sound and lower

marine survivals for all regions in Alaska has the potential to result in wide variability in wild pink and chum productivity.

In order to maintain or increase wild pink and chum populations while maintaining or increasing enhanced production and maximizing its harvest the following recommendations should be considered:

1. Marking of enhanced and wild pink and chum stocks (both juvenile and adult) could and should be used to design a harvest strategy to maximize harvest of enhanced stocks in mixed wild and enhanced areas while meeting escapement goals for wild stocks. Utilize this data in-season and post-season to estimate wild and enhanced components of the catch. Research into mass ~~*~~ marking of juvenile salmonids should be funded.
2. Institute test fisheries in various locations (catch to be used to pay for charter) throughout the fishing areas to evaluate their use in wild escapement management. Sample catches for marks. These charters could also be used for adult tagging for timing and migration studies.
- ~~*~~ 3. Study the freshwater productivity of wild stocks by estimating egg deposition and fry output in index streams. This is especially important if escapement goals are increased to determine if increased escapement results in higher fry output. This should also be carried out in streams pre and post logging.
4. Evaluate the effect of forest harvesting on egg-to-fry survival and spawning habitat capacity.

- * 5. Consider increasing the escapement goal to maximize wild productivity.
- 6. Evaluate the timing and migration of wild stocks and use stocks which will minimize wild and enhanced mixed fishery interception.
- 7. Evaluate future enhancement for site location and stocks selected to minimize wild stock interception. Manageability should be a major criteria in the permission process.
- * 8. Hold a small workshop of pink and chum management biologists from Alaska, B.C. and Washington to make recommendations for the management of enhanced and wild pink and chum stocks in Prince William Sound and South East Alaska.

no test fisheries in PWS

*Wayne
Donaldson*

(1)

Initially drafted by William R. Heard, November 15, 1991 as part of a team effort addressing a variety of questions regarding different issues and species of enhanced and wild salmon in Alaska.

CAN ABUNDANT WILD AND ENHANCED STOCKS OF CHINOOK SALMON CO-EXIST
IN ALASKA ?

This question is an outgrowth of the workshop held in Cordova Alaska, November 10-15, 1991 on the " Biological Interactions of Natural and Enhanced Stocks of Salmon in Alaska".

Chinook are the least abundant salmon in Alaska but are among the most highly prized and are often at the center of controversial fishery issues. Coastwide declines in the chinook wild stocks, especially in Washington, Oregon and British Columbia along with mixed stock ocean-troll fisheries in both countries were among the major factors leading to the Pacific Salmon Treaty between Canada and the United States.

One reason for the focus on chinook in the treaty was oceanic migration patterns of many stocks that migrate in a northwesterly direction along the U.S. and British Columbia coastlines. Many stocks of chinook become vulnerable to distant area fisheries. The troll fishery in Southeast Alaska was especially important because it caught large numbers of non-Alaska chinook originating from southerly stocks. Among other

(2)

things, the treaty called for limiting such interceptions of chinook between countries and states and for initiating a coordinated rebuilding program of depressed stocks along the coast. Other treaty provisions included a limit quota on numbers of chinook that could be caught in certain fisheries and an option for developing new stocks or groups of enhanced fish that could be harvested by the country or state of origin in addition to fish counted under the quota.

Chinook salmon hatcheries and significant related enhancement programs in southeastern Alaska have increased from two in 1976 to fifteen in 1990. New hatchery add-on provisions of the treaty was a major incentive for much of this development and the basic goal of this effort was to provide more chinook of local origin for Southeast Alaska fisheries. The primary targeted user groups for chinook salmon in this region are the commercial troll and marine recreational troll fisheries.

Most hatcheries in the region were developed with principles to have minimal impacts of hatchery fish on endemic wild stocks of chinook. Alaska Fish Genetic and Pathology Policy statements were important guidelines for selecting chinook hatchery sites, brood stocks, and enhancement practices. Unlike chinook hatcheries in many other regions, none were built on extant wild chinook streams. Most are located on islands 50 km to 200 km distant from wild stocks that are, with one exception on the mainland. Four primary hatchery stocks, derived from regional wild stocks, are in use in different parts of Southeast Alaska. Three other stocks have been involved in supplemental

(3)

enhancement of their depressed natal runs. Chinook brood stock selection for use in hatcheries and other enhancement efforts in this region is important because of differences in ocean migration patterns that result in different fishery contribution potentials for target fisheries. Upriver stocks from larger transboundry rivers (Taku, Stikine, Alsek) tend to have longer more distant ocean migrations than stocks from shorter coastal streams. Movements of eggs between hatcheries is carefully regulated based on stock, disease history and location of hatchery.

A formal interagency chinook plan for the region, with an annual annex update, provides oversight guidance on hatchery and other chinook enhancement activity within the region. The Chinook Plan Team and Plan Annex also serves as an annual monitor of individual hatchery broods relative to stock performance, fishery contributions and marine survival.

Production from both hatchery and wild stocks of chinook salmon in southeastern Alaska has steadily increased in recent years. Regional hatchery contributions to Southeast fisheries have grown from an average annual catch of about 5000 fish (1980-1985) to an actual estimated catch of 79,546 fish in 1991. After pre-treaty hatchery fish and risk factor adjustments are made, the hatchery add-on allowance for 1991 becomes 65,546 fish. One long term goal of enhancement in Southeast Alaska is to provide 100,000 add-on chinook to the commercial troll fishery. Total estimated escapements of wild chinook stocks in the region have doubled from an average of 43% of target goals (1975-1980) to 84%

(4)

(1986-1990). Target escapement goals for several wild chinook stocks within the region are increasing as better knowledge of spawner distributions within river systems becomes available.

* In view of the general increases in both hatchery and wild chinook production in southeast Alaska and taking into account the conservative approaches used in development of the chinook enhancement program, there does not appear to be major problem areas of adverse hatchery stock-wild stock interactions in this region. The only known possible exception involves small numbers of adult hatchery chinook recovered in non-natal areas. The majority of these known chinook strays have been recovered from areas without natural chinook runs, although a few hatchery fish have been found in some wild chinook streams. There is some concern for the specific stock presently used for hatchery and enhancement activity in the greater Juneau area because of the proximity of the Taku River and the possibility of hatchery strays into that system. Steps are in progress to use a more suitable hatchery stock in this area. In other regions of Alaska where there are chinook hatchery and enhancement activities, including Cook Inlet, there also are no known major adverse enhanced stock-wild stock interactions.

* Chinook program considered exemplary

INTERACTIONS BETWEEN WILD AND CULTURED SALMON IN NORWAY AND SWEDEN.

^{Norway}
Tor G. Heggberget

^{Sweden}
Torleif Eriksson

Atlantic salmon smoltify and leave freshwater at sizes between 12 and 17 cm. The smolt age vary between 1 and 6 years, depending on growth conditions during the presmolt freshwater period. The salmon return to freshwater to spawn after 1, 2, 3(4) years, at size from 1 to 25 kg.

Some significant life history variations between stocks exist. Examples of variations between stocks are: timing of spawning, timing of emergency of fry, timing of smolt migration, timing of return migration and age and size at maturity. Atlantic salmon in Norway are genetically distinct from the Baltic salmon.

NORWAY

In Norway there are three main sources of cultured fish;
1) Presmolt salmon released for general enhancement of stocks,
2) Ocean ranching - smolts released to compensate negative effects due to hydropower development and ocean ranching along the coast,
3) Escapees from pen farms along the coast.

There are about 500 streams with natural stocks of salmon in Norway. The production of farmed salmon in Norway was about 150 000 tonnes in 1991, while the natural production was about 2000 tonnes.

Problems:

- Due to pen farming activities a great number of farmed

salmon have escaped and are now mixing with the wild stocks.

- Proportions of cultured fish in spawning populations have increased during the last decade, and now exceed 80% of the total number of spawners in some streams.

- Parasites and diseases introduced with import of smolts from other countries have been transferred to wild stocks with some dramatic effects. High mortality of wild salmon have occurred both due to the parasitic monogenean *Gyrodactylus* and due to furunculosis.

- Ecological interactions, for instance competition during spawning and presmolt stages between wild and cultured fish have been observed.

- Genetic effects, interbreeding, may result in erosion of local adaptations in wild stocks of Atlantic salmon in Norwegian streams.

- Ocean ranching increase fishing pressure on wild stocks.

Negative effects of interactions between cultured and wild fish are tried to be reduced by:

- Convert from pen farming to land based salmon farming.

- Minimizing numbers of strayers from ocean ranching to wild stocks.

- Releases in connection to rivers (not directly in the sea).

- Harvest of ocean ranched fish apart from wild stocks.

- Releases away from important salmon streams.

- Locally/regionally based salmonid aquaculture. No transportation of live fish material between regions.

- Effective and intensive health control of release material.

SWEDEN

The Baltic stocks of Atlantic salmon have been subjected to impact of human exploitation for many centuries. At the end of 19th century salmon spawned in 60-70 rivers in the Baltic. From 1940 onwards many of the large salmon rivers were dammed and destroyed as spawning habitats.

To compensate for the losses hatcheries were established at the rivers used for hydroelectric power production.

Problems:

- Most natural populations have disappeared due to human activities in the rivers.
- Today between 80 and 90% of the catches in the fishery have a hatchery origin.
- The catches are dominated (80-90%) of off-shore catches on mixed stocks and represent a high exploitation rate on wild stocks.
- Wild stocks are unable to cope with the present exploitation rate while the reared stocks can due to high egg-to-smolt survival in the hatcheries. Thus only about 20-25% of the production potential in the natural rivers are actually produced today.
- Management plans are proposed including a reduction of the off-shore fishery.



Juneau Center for Fisheries and Ocean Sciences

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
11120 Glacier Highway
Juneau, Alaska 99801

(907) 789-4441 Office
(907) 789-4447 FAX

31 October 1991

The Honorable Senator R.I. Eliason
Alaska State Legislature
P.O.Box V (MS 3100)
Juneau, Alaska 99811

Dear Senator Eliason:

The workshop on the "Biological Interactions of Natural and Enhanced Stocks of Salmon" will soon start. I want to thank you for making travel funds available, which have enabled us to invite a large number of experts. Enclosed is a copy of the Agenda which is final except for a few minor changes or additions. Also enclosed is a copy of the final Prospectus distributed to the participants.

I shall keep you informed on our progress.

Sincerely yours,

Ole A. Mathisen
Ole A. Mathisen
Professor of Fisheries

Oct. 30, 1991

TENTATIVE AGENDA
Workshop on the
"Biological Interactions of Natural and Enhanced
Stocks of Salmon in Alaska"

Saturday, November 9

Participants arrive during the day.

6:00-7:30 pm Welcoming reception, at the Powder House
 (transportation provided).

All the planary meetings are held in the Masonic Hall (located at the north end of First Street). The daily schedule is as follows:

7:45 - 8:30 a.m. Continental Breakfast (at the Masonic Hall)
 8:30 - 10:00 a.m. First Morning Session
 10:00 - 10:30 a.m. Coffee Break
 10:30 - 12:00 Second Morning Session
 1:30 - 3:00 p.m. First Afternoon Session
 3:00 - 3:30 p.m. Coffee Break
 3:30 - 5:00 p.m. Second Afternoon Session

Sunday, November 10

First Morning Session - 8:30-10:00 a.m.

Opening remarks:

1. G.L. Thomas, Director Prince William Sound Science Center
2. Goals of the Conference - Ole Mathisen, Univ. of Alaska-Juneau
3. Prince William Sound Aquaculture Corporation - John McMullen, President
4. State Genetic Policy - Jim Seeb, Alaska Dept. of Fish & Game

Session 1 -- Ocean carrying capacity
 10:30-12:00

1. A theoretical evaluation of the carrying capacity of Prince William Sound, Alaska for juvenile Pacific salmon.
 R. Ted Cooney
2. Density dependent changes in chum salmon, *Oncorhynchus Keta*, returning to Iwate Prefecture, Japan. Hitoshi Ida
3. Factors affecting marine growth of Bristol Bay sockeye salmon.
 Don Rogers

Agenda - Page 2

4. *Interaction in natural carrying capacity limitations for natural and enhanced stocks of salmon.* Percy Washington

Session 2 -- Management of mixed stocks

1:30-3:00 p.m.

1. *Trends in abundance of hatchery and wild stocks of pink salmon in Cook Inlet, Prince William Sound and Kodiak, Alaska.*
Doug Eggers
2. *Management of mixed enhanced and wild salmonids in British Columbia.* (B.E. Riddell unable to attend - replacement???)
3. *Gene frequencies and the management of Pacific Salmon: Identification of wild and hatchery fish in mixed fisheries.*
Jim Seeb

Session 3 -- Summary and general discussion

3:30-4:30 p.m.

Evening

Seafood dinner at the Reluctant Fisherman
Social hour, 6:30 p.m.; Dinner, 7 p.m.

Monday, November 11

Session 4

8:30-10 am -- Basic Genetic Structure

1. *Conservation of genetic diversity in salmonid fishes: why, what and how.* P.W. Allendorf
2. *The productive value of stream distances for estimating genetic relationship in salmonid species.* Fred Utter
3. *Population structure of chum salmon.* Lina Seeb
4. *The importance of fine genetic structures in natural populations.* Tony Gharrett

Session 4 continued

10:30-12:00

5. *Quantitative genetic variation of life history traits in pink salmon.* William Smoker
6. *Genetic stock identification of Yukon River chum and chinook salmon.* Richard Wilmot

Agenda - Page 3

7. *Genetic stock identification of Bristol Bay area salmon.* Rebecca Everett.

Session 3 -- Straying
1:30 - 2:00 pm

1. *Homing, straying and the interaction between wild and enhanced stocks of salmon.* T.P. Quinn
2. (TBA) Sven Ebbesson (unable to attend -- paper to be distributed?)

Session 6 -- Long Term Case Histories
2:00-3:00 pm

1. *Interactions between wild and cultured Atlantic salmon -- A review of the experience in Norway.* Tor Heggberget
2. *The status of wild and hatchery propagated Swedish salmon stocks after 40 years of hatchery releases in the Baltic rivers.* Torleif Eriksson

Session 6 continued
3:30-5 pm

3. *The status of the Snake River chinook.* Ernest Brannon
4. *The Soviet experience in the field of salmon interactions.* Mikhail Glubokovsky
5. General discussion

Tuesday, November 12

Field trip to Wally Norenberg Hatchery at Esther Island (western Prince William Sound) -- Weather dependent, this may be delayed until Wednesday.

Wednesday, November 13

Session 7 -- Interactions in Prince William Sound
8:30-10 am

1. *Historical production of wild and enhanced stocks of pink salmon in Prince William Sound.* Sam Sharr