1. INTRODUCTION

The primary goal of the Fisheries and Oceans Wild Salmon Policy (WSP) is to:

"Promote the long-term viability of Pacific salmon populations in natural surroundings, and fish habitat for all life stages, for the sustainable benefit of the people of Canada"

Under the policy, three principles have been established to guide decisions and activities that affect the conservation of salmon.

1. Conserve wild salmon by maintaining diversity of local populations and their habitats
2. Acknowledge and protect the key role that wild salmon play in their ecosystems
3. Establish operational guidelines consistent with best practices in risk management for carrying our harvest, habitat, and fish cultivation activities.

Fish cultivation activities include both aquaculture and salmon enhancement. This document addresses the operational guidelines for fish cultivation activities for salmon enhancement. It describes enhancement history and strategy, the kind and degree of risks that are relevant to cultivation for salmon enhancement, strategies by which these risks can be mitigated and how cultivation can be accommodated within the WSP framework. In many instances, risk mitigation involves the use of guidelines and protocols. Appendix 1 of this document includes these detailed guidelines and protocols.

Scope of the Guidelines

In the Pacific Region, the term "enhancement" has come to encompass a broad range of activities that are designed to increase, recover and protect salmon stock productivity. These include hatcheries or spawning channels that use fish culture techniques, habitat restoration and protection, lake enrichment, and public outreach.

The enhancement activities addressed in this document are a product of the definition of a wild salmon. The WSP defines a wild salmon as "a salmon produced by natural spawning in fish habitat from parents that were spawned and reared in fish habitat." Accordingly, salmon that result from habitat restoration or lake enrichment activities will be considered wild because of their spawning history. The scope of this document is therefore limited to salmon enhancement activities that use *fish culture* techniques where major intervention in at least one life history phase may affect natural selection. This will include:

- hatcheries
- community incubation projects
- managed spawning channels where salmon spawn timing and density are intensively controlled.

The components of the enhancement program which focus on issues relating to habitat, (including lake enrichment) and which promote working toward a net gain in productive capacity of salmon habitat. in BC, .are consistent with existing policy including the "Policy for the Management of Fish Habitat in Canada". These components will be addressed with the operational guidelines for habitat management

Fish Culture and the Wild Salmon Policy

Many reviews (add references) of hatcheries and fish culture have been undertaken in other jurisdictions. Although the broad categories of risks associated with enhancement are well known and well catalogued, the specific risks and the degree of risk involved are unique to each program and indeed, to each project. Different modes of execution, differences in best management practices and a more recent program than many U. S. jurisdictions have resulted in a risk environment for B.C. fish culture that is quite different in many respects than that portrayed in much of the literature.

Undeniably, poorly planned and managed fish culture can pose risks to wild salmon. It can affect genetic diversity, attract fishing effort that can deplete less productive co-migrating stocks, and result in ecological impacts. However, when these risks are well managed, fish culture can afford substantial benefits by providing commercial, recreational and First Nations fisheries, supporting the recovery of threatened stocks, providing assessment information in support of wild stock management and assessment, and supporting conservation through hatchery outreach programs. Fish culture can make a substantial direct contribution to conservation. As well, it can contribute to the achievement of broader social and economic goals by creating and maintaining salmon production at levels beyond that sustainable naturally.

These guidelines reflect the use of the best available science to reduce the potential that wild salmon will be unintentionally harmed from the production of enhanced salmon. They reflect a social decision to accept managed risk in order to obtain benefits. At the same time it is acknowledged that the willingness to accept risk will vary by user group. These guidelines are intended to facilitate constructive dialogue towards consensus on these matters.

The future of salmon enhancement will be largely based on what science learns regarding cultured salmon and how they interact with wild salmon in the natural environment and on the cultural, economic and environmental value the people of Canada place on the salmon resource. These guidelines will evolve over time as more becomes known about these matters. The overall intent is to provide for the protection of the wild salmon resource for future generations while meeting the needs of present generations for the benefits that salmon provide.

2. ENHANCEMENT BACKGROUND

2.1. Enhancement History

Somewhat like salmon, fish culture facilities and programs have cycled in abundance over time. Beginning in the early 1880s, a number of sockeye hatcheries were built throughout BC. On the basis of quite limited scientific studies demonstrating negligible returns at a couple of those hatcheries, the government closed all hatcheries in the late 1930s. Interest in fish culture began to build again in the 1950s, both with the construction of the world's first spawning channel at Jones Creek, and with the success that U.S. fisheries agencies were showing at their chinook and coho hatcheries. These new hatchery techniques were first tried in BC at Big Qualicum River during the late 1960s. Major sockeye spawning channels also were built during the late 1960s on the Fulton and Pinkut tributaries to Babine Lake. BC's use of both spawning channels and hatcheries began to escalate, in large part to mitigate for habitat losses due to major developments such as dams.

By 1970, the technology for producing large numbers of salmonids was considered in hand, and a proposal to build state-of-the-art hatcheries around the Strait of Georgia was accepted by the Minister of Fisheries. The Capilano Hatchery was the first of these, and was completed in 1971; it was followed by the Quinsam Hatchery in 1974. In 1975, Cabinet approved a two-year planning project to develop the concept of a province-wide Salmonid Enhancement Program. *"Through a combination of natural and artificial enhancement techniques, it is hoped that [salmon stocks]...would again be at the abundance that they were at the beginning of the century."* (SEP News Release dated 5 Oct 1976). In addition, there was a stated fear that *"...Canada, a world leader in salmon technology, stands in danger of being left behind"* by other Pacific Rim nations that were undertaking massive enhancement programs (Framework of Strategies Discussion Paper, Appendix II-11 of Salmonid Enhancement Program Proposal).

Phase I of SEP was announced in 1977. SEP was to use a "Five Account" system to calculate benefits: National Income; Regional Development; Benefits to Native People; and Benefits to the Environment. Stock rebuilding was delivered through hatcheries and spawning channels operated by DFO, as well as First Nations and community groups. Individual projects were designed to supplement natural salmon production and to contribute to fishery, cultural and socio-economic objectives. To assess progress, the program had specific performance measurement criteria, including benefit-cost evaluation and an intensive monitoring and evaluation component.

Phase II was to begin in 1983, building on the results of Phase I. However, Phase II approval and funding was delayed until 1987, largely due to growing fiscal restraints. Due to budget constraints and increasing controversy over the risks of large-scale enhancement to wild salmon, no new hatcheries were built after 1985 (although a number of "unmanned" spawning channels were constructed in the late 1980s into the early 1990s). Also to address budget shortfalls, a number of facilities that did not meet performance objectives were closed. In Phase II, the program focus shifted to rebuilding depleted stocks (not necessarily for harvest purposes), more 'natural" forms of enhancement such as habitat restoration and increased efforts to integrate harvest and habitat management efforts with stock rebuilding.

Fish culture facilities also were initiated outside of SEP by community groups, or under the auspices of the Aboriginal Fisheries Strategy. SEP staff also provide some technical support to these facilities. Appendix 2 provides more detail on the SEP.

Much has been learned from fish culture efforts to date, but much more remains to be learnt. Some would recommend that we once again close all hatcheries, but this likely would condemn us to repeat mistakes in the future. Rather, we need to pull the lessons learned into a comprehensive framework that will allow us to continue to keep fish culture techniques in the toolkit. Like the difference between a chainsaw and a handsaw, fish culture may be able to do some jobs more quickly and efficiently, but there is also some additional risk, both to the operator as well as the project! The guidelines outlined in the following sections of this document are meant to manage and minimize such risks. Their use should allow a balanced mix of activities for the long-term benefit of salmonids and society under the auspices of WSP.

2.2. Enhancement Strategy

The DFO fish culture program follows an *integrated* production strategy for Pacific salmon. Integrated programs are those where cultured fish are released as juveniles to reside in the ocean, and then return to spawn in natural habitats in the systems from which they originated. Cultivated fish are intended to become fully reproductively integrated with wild salmon within local populations. As a consequence, the program has from the outset endeavoured to maintain the demographic and genetic characteristics of returning cultured salmon to be as similar to the parent wild stock as possible. Key practices in maintaining such characteristics are the use of native broodstock where possible, prescribed broodstock collection methods and spawning practices and evaluation of survival, return rates and contribution.

The integrated production programs common to DFO's. fish culture programs are in contrast to *segregated* production programs that are designed to minimize the number of artificially propagated fish spawning in natural habitats or interacting with natural populations. Because these progeny were not intended to merge with natural populations, there was sometimes less concern about maintaining genetic similarity to the natal population. In some segregated programs the genetic differences between the hatchery and wild stocks may be large, as broodstock were transplanted from diverse origins. This can result in widespread straying and loss of native broodstock which in turn can confound efforts to rebuild small native populations . Some segregated programs have resulted in complex problems that require complicated, expensive solutions involving extensive changes to hatchery infrastructure and marking of all hatchery fish. This mass marking ensures that hatchery fish are identifiable and can be removed from the population or otherwise prevented from spawning with wild fish. DFO also conducts mass marking programs (e.g. Southern hatchery coho) but these programs are designed to allow hatchery mark selective fisheries, not as a tool for isolating hatchery fish from wild spawners.

While segregated production programs are common in other jurisdictions, they are rarely done here. The distinction between these two strategies is important. Because the DFO fish culture program was designed as an integrated strategy, many of the concerns that have arisen with programs in other jurisdictions were avoided. Further, the program incorporated guidelines (Appendix 1) and protocols at the outset to ensure genetic integrity. The WSP will provide the framework to codify these practices as well as to refine and update them as new science becomes available.

3. RISK CATEGORIES OF SALMON ENHANCEMENT

The impacts that hatchery salmon can have on wild salmon populations have been widely reviewed in the literature. (add references) These impacts may be genetic, ecological, or demographic and may affect the same species or other species. They may be minimized or in some instances eliminated, by the use of good planning processes before projects are established, the application of best management practices through guidelines and protocols, and the implementation of adaptive management based on ongoing monitoring and evaluation.

The following section summarizes the categories of risk associated and a general description of guidelines and other practices intended to manage those risks. Specific protocols and guidelines applicable to operational components are included in Appendix 1.

3.1. Genetic (ref: Puget Sd. comprehensive chinook management plan, Waples)

3.1.1. Risk Description

Genetic concerns revolve around loss of genetic variation in populations. Genetic effects from fish culture include the loss of diversity among populations, loss of within population diversity and domestication. These sources of genetic effects have been extensively reviewed in Campton, 1995 and etc.

- Loss of among population genetic diversity is associated with straying of local populations to other systems or human transfers of non-local brood stock with subsequent interbreeding. Depending on the magnitude of the straying, this can lead to loss of important adaptive differences between populations and reduce the ability of populations to respond to rapid environmental change and well as to reproduce.
- Loss of within-population genetic diversity, or inbreeding, is the result of the mating of related individuals and can be of particular concern for small populations. If sufficiently pronounced, it can result in in-breeding depression, which is a reduction of fitness of the individuals.
- Domestication is the intentional or unintentional selection for adaptation to an artificial environment. Adaptation to a hatchery environment, while unavoidable, may hinder the ability of the fish to survive in a wild environment..
- The excessive removal of brood stock from escapements ("brood stock mining"), where few animals are left to spawn naturally, can also impart genetic effects.
- There are risks in allowing conservation units or local populations to decline to levels where there are negative genetic effects, particularly where we may not fully understand the population structure of the conservation unit. Depleted populations also do not contribute to fishery and ecosystem function. Admittedly, these individual populations could be at some risk of genetic effects due to fish culture techniques but these risks must be balanced against small population size.

3.1.2. Risk Mitigation

- Inbreeding risks can be significantly reduced through the use of broodstock collection practices and spawning guidelines. Broodstock collection guidelines prescribe the collection of sufficient numbers of broodstock to represent the entire donor population and minimize inadvertent selection. (Appendix 1 – guideline x) Spawning guidelines dictate protocols for mating and fertilisation methodology and are designed to be specific to the number of animals to be spawned. (Appendix 1 – guideline x). In order to address brood stock mining, guidelines also limit the proportion of the escapement that may be collected when undertaking stock rebuilding.

- Because hatchery and wild environments exert different selective pressures on juveniles, some degree of domestication/selection may be unavoidable. However, it can be minimized through the use of guidelines for rearing and release practices. (Appendix 1 – guideline x)
- Outbreeding depression can be minimized through the use of rearing and release practices that reduce straying . (Appendix 1 – Guideline x) and the use, wherever possible, of local broodstock. Where non-local broodstock are used, their transfer and use is reviewed by the joint Federal/Provincial Introductions and Transfers committee. The committee reviews transfers from the perspective of ecological, genetic and disease risks and allows only those transfers that are anticipated to have minimal genetic impacts on native stocks.

3.2. Demographic (although this is general usage, an alternate term would be helpful)

The demographic risks from enhancement involve fisheries and their impacts on non-target populations. Impacts can include overfishing and overshadowing of trends in wild stock status.

3.2.3. Risk Description

- *Overfishing* - Demographic effects of hatcheries on wild salmon can result from intensive fishery effort on the enhanced stocks that will affect accompanying wild stocks. When harvest rates are set at levels that can be withstood by enhanced stocks, other less productive, co-migrating stocks may be over-harvested. This is of particular concern when fisheries are undertaken in mixed stock areas but is not the exclusive purview of enhancement as fisheries management has always been challenged by the execution of fisheries on stocks of differing productivity.

- *Obscuring trends in wild stocks* - Hatchery production may mask trends in wild abundance, and in so doing overshadow declines in wild stock status. Theoretically, this could slow implementation of harvest reductions that would normally be invoked when stock levels decay. As well, a high rate of straying of unmarked spawners of cultured origin to an unenhanced system may mask declining escapements of wild fish.

3.2.4. Risk Mitigation

- *Overfishing* – Mitigation for demographic risks begins with planning process. The demographic risks associated with hatchery production can be ameliorated by good planning that includes a clear definition of harvest objectives and where and how harvest will occur. Such planning should ensure that objective are indeed achievable without unacceptable risks to other wild stocks. As much as possible, harvest strategies should be of a terminal or selective nature. Resource management operational guidelines will describe a process for establishing appropriate harvest rates,

- *Obscuring trends in wild stocks* - Monitoring and evaluation of enhanced stocks is an overall guideline to minimize enhancement risks. Such evaluations for hatchery assessment can also, by inference, provide information on wild stock trends and so, elucidate, rather than mask, wild stock trends. It can be argued for example, that when Thompson coho declined precipitously, the tagging programs that were designed to evaluate hatchery releases provided the critical information necessary for stock assessment analyses and appropriate harvest reduction responses. Resource management operational guidelines will describe an assessment framework for monitoring stock status.

3.3. Ecological

3.3.5. Risk Assessment

Ecological effects of hatchery salmon can include displacement of wild juvenile salmon in freshwater rearing environments as well as competition for food and space. There are also concerns about the carrying capacity of the marine environment. Finally, there have been concerns from an ecological perspective about the reduction in nutrient replacement from spawning salmon as a result of brood stock removal.

- *Juvenile Freshwater* - For species with a freshwater juvenile life history phase, hatchery juveniles can competitively displace wild juveniles in the freshwater rearing environment if release strategies are not well managed. If freshwater habitats are fully subscribed by wild juveniles, larger hatchery juveniles released at a later timing than wild fish may displace wild juveniles. Alternatively, if larger hatchery juveniles released at an earlier timing than wild fish have taken up in-stream residency, they can prevent wild juveniles from establishing and occupying territories.

- *Adult freshwater* – Recent work has indicated that salmon provide a critical pathway by which marine nutrients, primarily phosphorus and nitrogen, are transported into rivers and forests along the North Pacific Coast. Concerns have been expressed that hatcheries reduce the opportunity for returning spawners to contribute to nutrient recycling because of brood stock removal.

- *Marine carrying capacity* – Recent fluctuating survival rates and marine distribution patterns for southern coho as well as frequent El Nino events and changes in marine climate indicators have led to concerns that marine carrying capacity is unstable and that there may be shifts in the productivity of marine waters. Long term changes in the environment may also result from global warming. The particular concern for cultured fish is that that they may be displacing wild fish in an environment limited by carrying capacity.

3.3.6. Risk Mitigation

- *Juvenile Freshwater* - Impacts of this nature are very specific to the population and the stocking strategy. They can be minimized by the use of rearing and release guidelines that reduce juvenile competition by releasing juveniles at appropriate sizes and times. (Appendix 1 – guideline x) Guidelines that acknowledge stream carrying capacities and existing wild biomass are also used to guide stocking biomass (Appendix 1 –guideline x).

- *Adult Freshwater* - For many depressed systems, returns have been declined so severely that salmon no longer play a significant role in ecosystem function. In these instances, the removal of the few salmon for brood stock would have little impact on nutrient availability. Hatcheries can in fact benefit nutrient re-cycling by re-building runs to maintain adequate numbers of spawners. The department has developed guidelines for in-stream carcass placement so that carcasses of broodstock or other returns to the hatchery rack may be replaced into the system of origin. (Appendix 1 – refs)
- *Marine Carrying Capacity* – Much scientific uncertainty surrounds marine carrying capacity, and there is no clear understanding of the impact of significant increases in the number of one species relative to others, whether wild or cultured. The department needs to commit to relevant research and incorporate increases in understanding in guidelines. We cannot underestimate the affects that future climate change may have on our ability to understand, predict and manage stocks..

3.4. Disease Transference (much of this directly from Waples and Puget Sound chinook management plan)

3.4.7. Risk Description

The pathogens responsible for fish diseases are present in both natural and hatchery populations. Hatchery populations may have an increased risk of expressing pathogens because specific hatchery conditions (e.g. higher densities) may stress fish or lower immune response. If not well managed, pathogens may be transported outside of the hatchery through effluent or through the release of untreated infected fish. However, it is important to remember that many of these diseases are endemic to natural populations and many populations have evolved adaptive strategies for dealing with them. Waples, 1999, noted that there is little or no direct evidence of transfers of pathogens from cultured to natural populations, in spite of apparently widespread opportunities for this to occur, but did acknowledge that there is little baseline information on wild, pristine populations.

3.4.8. Risk Mitigation

- Appendix 1 – guideline x describes general hatchery practices that are designed to stop disease from entering or leaving hatcheries. Fish health management plans address feeding and handling practices to reduce stress as well as health monitoring, effluent management, and disease screening. If disease outbreaks occur, guidelines prescribe containment practices. There are also protocols for the management of manage specific pathogens (Appendix 1 – guideline x).
- All transfers of fish or gametes, from one site to another, even temporarily, are reviewed by the joint Federal/Provincial Introductions and Transfers committee for disease risks. The committee assesses and manages disease risks according to the Fish Health Protection Regulations. Broodstock carcasses moved outside the hatchery for carcass placement replacement are managed by protocol to minimize disease risk. (Appendix 1 – guideline x).

- All disease outbreaks at hatcheries are reported to the Fish Diagnostics group for diagnosis and appropriate management and treatment response. Reponses are consistent with Fish Health Protection Regulations and the diagnostics group includes licensed Fish Health Professionals. A database is maintained on all disease outbreaks.
- Additional precautionary measures may be needed as knowledge base increases such as eliminating the juxtaposition of juvenile netpens with adult migratory routes.

4. LINKAGES TO RESOURCE MANAGEMENT UNDER THE WILD SALMON POLICY

4.1. Concepts

Under the terms of the Wild Salmon Policy, wild salmon will be managed and conserved as (aggregates of local populations called) *conservation assessment units*. Conservation assessment units are "a group of one or more local populations that share a common genetic lineage and can be managed effectively as a unit by virtue of their common productivity and vulnerability to existing fisheries." Decisions about harvest management, cultivation, or other activities will be guided by benchmarks of abundance for each conservation unit. These reference points will bound zones that reflect the status of the conservation unit and within which specific responses will be developed to achieve the conservation and other management objectives for the unit.

Where cultured and wild salmon mingle, "the WSP applies to all wild salmon, including those mixed with enhanced salmon that are able to reproduce in natural surroundings"

4.2. Treatment of Individual Populations within Conservation Units

Within conservation units, individual local populations may be depleted or at risk of extirpation, even when the overall health of the conservation unit is satisfactory. Although such populations may be re-populated over time by salmon straying from other populations within the conservation unit, the stock status and the projected time frame of re-population may not be deemed acceptable. In these circumstances, fish culture may provide a strategic means of conserving these individual salmon populations at most risk of extirpation by directing efforts at the local population level, rather than at the higher level of the conservation unit. This ability to work at the finer scale of the population or sub-population will meet or exceed WSP criteria for conserving groups of related populations and would provide a means of ensuring that salmon continue to both play their important role in the ecosystems and meet stakeholder objectives.

For enhancement purposes, execution at the population level is key to conservative management of genetic resources. It is recognized that even when local populations reside within the same conservation units, indiscriminate transfers of fish between locally adapted stocks could disrupt local genetic adaptations.

4.3. Role Of Enhancement In Conservation Unit Rebuilding

When abundance within a conservation unit falls below its established precautionary reference point, some immediate measures will be taken to reduce exploitation rates in the fishery. In addition, a management review will be initiated to identify the causes of the decline and the likely impacts of alternative management measures on the timing and likelihood of conservation unit re-building. The potential for fish culture to contribute to the speed and likelihood of conservation unit re-building will be explicitly considered in this management review. An overall re-building strategy for the conservation unit will be selected in consultation with stakeholders. Specific fish culture initiatives may form part of an integrated re-building strategy for these conservation units.

When abundance within a conservation unit falls above its precautionary reference point but below the abundance associated with Maximum Sustained Yield, consultations with stakeholders will be initiated to identify an appropriate target abundance level for the conservation unit. Where re-building of the conservation unit is appropriate, short and medium term re-building goals will be further identified. Depending on the outcome, a fish culture response may be warranted for the conservation units (or for specific populations within the conservation unit) and according to the departmental decision rules. Fish culture will be focussed at the local population level.

4.4. Management of Enhanced Populations within Conservation Units

Because enhanced salmon are integrated with wild salmon of the same conservation unit, the abundance of cultured salmon must be considered in setting reference points and management activities. In those instances where the fish culture objective is to support a harvest, it may be prudent to consider the cultured and wild portions of the population as one single population and to assign it to its own conservation assessment unit. For example, the Robertson Creek chinook population is largely of cultured origin and the stock is used as a stock assessment indicator for chinook populations on the West Coast of Vancouver Is (WCVI). If the reference points are based strictly on the abundance of the wild portion of the population, wild salmon abundance levels may never be adequate for a fishery, in spite of the fact that total abundance is very large. Conversely, if the population is considered in aggregate as an indicator within the WCVI conservation assessment unit, its abundance may drive fishery patterns that are insupportable for wild stocks.

Where fish culture is identified as part of a rebuilding strategy for populations of conservation concern, cultured salmon will be afforded the same protection as wild fish. For example, decision rules for the Cultus lake recovery plan invoke a fish culture response when escapements are small. If the Cultus sockeye that originated from fish culture were not protected in the same way as wild salmon, it could undermine the rebuilding strategy.

5. WSP - OPERATING STRATEGIES FOR ENHANCEMENT

5.1. Overall operating strategies

In general, fish culture objectives should be incorporated into planning processes such as the Watershed Fish Sustainability Process (WFSP) or Integrated Fisheries Management Plans (IFMP) and reflect stock status, community and stakeholders objectives with regard to desired future condition for the conservation unit and the stock and indicators of performance relative to objective. Resource management operational guidelines will describe IFMP planning processes for conservation assessment units. Planning will include consideration of fish culture to reach objectives but fish culture will by no means be an automatic response. Furthermore, although it is acknowledged that objectives can change as projects mature, these changes must be addressed by re-entering the planning processes.

Fish culture programs will operate within a set of general operating guidelines in support of the WSP.

- ***Fish culture projects will have clearly stated objectives, evaluation methods and performance measures***

There must be an explicit objective for every fish culture project and a plan that incorporates evaluation and performance relative to goals. There should be explicit objectives for specific salmon populations and their ecosystems.

- ***Fish culture projects must have adequate evaluation and monitoring programs that are appropriate to their objectives***

Evaluation programs must be designed to measure progress relative to objectives, as well as monitoring programs that assess impacts on wild salmon.

- ***Fish culture projects must be based on adaptive management practices.***

The results of evaluation and monitoring of programs must be assessed and incorporated where appropriate into management practices to ensure that there is continuous learning and improvement within and among projects.

Fish culture projects must be part of area watershed, harvest or other planning processes in order to minimize risks to wild populations and maximize benefits.

Fish culture programs cannot operate in isolation from watershed or harvest planning processes. They must be integrated into an overall approach for the population.

- ***Fish culture projects need to assess and manage the risks to wild populations through the use of adequate protocols and guidelines.***

The guidelines and protocols that are pertinent to fish culture project must be incorporated into operating practices.

5.2. Fish Culture Objectives under the WSP

Fish culture can be accommodated within the framework of the WSP and utilized to fulfil a number of objectives including rebuilding stocks, supporting harvest, providing stock assessment information and meeting educational needs.

These objectives may be considered in two broad categories:

- conservation– including rebuilding through a range of stock status levels (from high risk of extirpation to anywhere in the conservation unit rebuilding zone, including re-establishment of extirpated populations), mitigation for habitat loss, provision of stock assessment information or providing educational or viewing opportunities
- sustaining fisheries– provision of First Nation's access to food, social or ceremonial opportunities, supporting a hatchery rack, terminal, selective or other sustainable fishery,

Regardless of the fish culture objective, all projects will follow guidelines to ensure the long term sustainability of the resource. However, for some operational components different guidelines may be required to meet the specific requirements of the objective. For example, the spawning guidelines for a small stock with endangered status will require a different spawning protocol to that of a large stock comprised of hundreds of individuals.

5.2.9. Conservation Objectives

5.2.9.1. Contribute to recovery efforts for C.U. abundance below the precautionary reference point

When conservation assessment unit abundance falls below its established precautionary reference point, a management review will identify the likely impacts of alternative management measures on the timing and likelihood of re-building. The potential for enhancement to contribute to the rebuilding of local populations within the conservation assessment unit will be explicitly considered in this management review and specific enhancement initiatives may form part of an integrated re-building strategy.

Technical operational guidelines are particularly important during the rebuilding phase for stocks of conservation concern as population size is small and the potential for negative genetic selection and drift high.

5.2.9.2. Contribute to rebuilding of depleted populations (Between Precautionary Ref Pt. and TRP)

Where populations are demonstrated to be depleted but not of serious conservation concern, and, if deemed appropriate through a watershed fish sustainability plan or other planning process, fish culture may be considered as a means of population rebuilding. The objective of such rebuilding is to return the population to ensure that the population is at self sustaining. Fish culture will cease when targets have been attained. The rebuilding target may be based on present habitat conditions or to levels more consistent with historical habitat conditions to meet the ecological needs of their respective watersheds. There would however, be no intrinsic departmental responsibility for enhancement of every depleted stock.

If after rebuilding, it is desired to maintain fish culture to now meet a harvest objective, the planning process must be re-entered.

5.2.9.3. Mitigate for critical habitat loss

Fish culture could be considered as a strategy to maintain populations in affected habitat until habitat restoration efforts are effective, but this must be approached with caution. Aside from the WSP, DFO also must follow the No Net Loss Policy. The Habitat Conservation and Protection Guidelines (2nd Ed, 1998) state that the *"...option of artificial propagation involves replacing in whole or in part the natural productive capacity of fish habitat with artificial production. This option should be considered only in rare cases where...this course of action is in the public interest."* Under the Hierarchy of Compensation Options (Practitioners Guide to Compensation, 2002 MS), artificial propagation may be considered as a tool to sustain populations in the absence of viable habitat, but it is identified as a "Measure of Last Resort" and a least-preferred option. Prior to the release of the NNL Policy, this strategy was used for a number of facilities, including the Capilano River Hatchery. However, experience has demonstrated that this option is invariably costly and - unless capable of providing other benefits such as education - of questionable value where populations can never become self-sustaining. This strategy is now seldom entertained. For example, during the 1986 Settlement Agreement deliberations regarding the Kemano Completion Project, it was agreed that fish culture facilities would be considered only if and when the Nechako chinook run was in danger of extirpation.

5.2.9.4. Provision of Assessment Data

In the course of hatchery evaluation and monitoring, large numbers of fish are marked at a number of hatcheries to allow statistical analyses of returns. Many hatchery stocks have been marked since the late 1960s, and thus have a long time series of data. This information is also used for the assessment of wild stocks and marked hatchery stocks provide much of the critical data for determining catch distribution, survival and exploitation rates. For example, the chinook analytical component of the Pacific Salmon Treaty is based on coded wire tag data from hatcheries. Pearce (1994) noted that "the present mark recovery program is regarded by experts as one of the world's best. It would be difficult and costly to maintain such a program in the absence of enhancement facilities."

For most facilities, provision of stock assessment information is not the primary objective of enhancement. However, in some instances, enhancement is undertaken chiefly to supply fish that may be marked for the generation of stock assessment data. Such data contribute directly to the conservation of wild salmon by providing data for stock assessment and harvest management. For example, the culture of Dome Cr. chinook on the upper Fraser was originally undertaken to rebuild the population. The population is now relatively healthy but because the data generated from the project have become invaluable tools for Upper Fraser chinook assessment, fish culture has been maintained. There are no other tools for obtaining the same data

5.2.9.5. Education – school and outreach programs

Small fish culture programs using aquarium incubators are often part of school education programs. Although, small numbers of juveniles are released, the conservation value of these programs is in the education about the resource that they provide, not in stock rebuilding. Transplant and release guidelines (Appendix 1, guideline x) are utilized for these programs.

5.2.10. Sustaining Fisheries

The department will endorse provision of harvest opportunities through fish culture as an acceptable objective where risks to are not detrimental to other stocks and species on balance within the decision making process (decision making framework to be developed). This endorsement does not imply fiscal responsibility, however. Although the department currently funds fish culture for harvest opportunities, over time, funding contribution arrangements may be considered.

Fish culture may be undertaken to increase populations above their natural productivity to establish and maintain harvest opportunities for First Nations fisheries or for recreational or commercial sectors. These are fisheries that would not occur or would be significantly constrained without the contribution of cultured salmon. *This objective will result in returns to the targeted populations that are predominantly comprised of fish of cultured origin. Furthermore, the population may be managed as an aggregate such that protection is accorded to all salmon within this population.* Where possible, these fisheries should be terminal or selective (e.g. mark selective fisheries, locate fisheries within enhancement facilities.) However, even where the fish culture objective is to support a terminal fishery, cultured fish may contribute to other non-terminal fisheries along their migratory route. The range of fisheries that fish culture may support includes:

- Recreational fisheries that target primarily cultured salmon. For example, hatchery mark only selective fisheries allow harvesters to retain marked hatchery fish only while releasing unmarked fish. These fisheries may occur terminally and target single marked populations, such as in the Chilliwack River, or in the ocean, such as the Georgia St. hatchery mark selective fishery, where a number of marked stocks may be harvested.
- Commercial fisheries that target predominantly cultured salmon either terminally and in close proximity to the hatchery, e.g. Nitinat chum, or in-river but at some distance from the culture facility e.g. Skeena sockeye
- Pilot cost recovery fisheries where the fish culture objective is to support the project through funds generated by cost recovery fisheries on surplus fish. Three facilities (Nimpkish, Pallant, Theodosia) are piloting this approach in B.C. These fisheries may occur within the enhancement facility ("rack" fisheries), in close proximity to the facility or at some distance.
- Fisheries that target cultured salmon that are excess salmon to spawning requirements (ESSR licences) fishery. These fisheries may occur within the enhancement facility ("rack" fisheries), such as at Inch Creek, in close proximity to the facility (Nitinat chum) or at some distance, e.g. Skeena sockeye.
- Food, social and ceremonial fisheries that target predominately cultured fish, either within the enhancement facility, in close proximity to the fish culture facility or at some distance,.
- Mixed stock fisheries where small stocks are being incidentally caught. Culture of the weaker stocks within the aggregate may allow a higher harvest of the stock aggregate and thus allow a fishery an interception fishery to be maintained. e.g. enhancement on Sarita chinook in Barkley Sd. maintains this small stock in the face of the large chinook fishery in Barkley Sd.

6. NEXT STEPS

Although guidelines, evaluations and monitoring have been in use since the programs' inception, not all projects use the same kinds of guidelines, nor are they evaluated in the same way. Some guidelines are not applicable to particular kinds of projects and application of guidelines may be deficient in some circumstances. Similarly, some projects do not lend themselves well to all evaluation components.

In order to ensure that projects are operating in the most risk averse manner under the WSP the next steps will involve a review of all DFO-funded enhancement facilities, including government, First Nations, and community facilities to assess and establish:

- specific goals and objectives and performance measures
- performance relative to goals

- adherence to applicable guidelines and protocols.
- Best management practices that incorporate guidelines and protocols.

APPENDIX 1 - SPECIFIC OPERATIONAL GUIDELINES (one example guideline included)

GENETICS PRACTICES FOR HATCHERIES

The objective of genetic guidelines is to preserve as much as possible the entire range of genetic material of a given population. Appropriate brood stock selection and spawning practices can minimize genetic selection and maximize the genetic variability of the population. The proper use of sufficient broodstock is essential in order to minimize undesirable genetic effects, such as inbreeding.

BROOD STOCK SELECTION

1) **Source**

   a) Use native stock first. If there is no alternative, transplant approaches such as the following may be acceptable:

      - hybridize with closely related stock
      - transplant closely related stock
      - develop a hybrid stock from a number of closely related stock

Transplants must be part of a longer term area plan and must be approved by the transplant committee. See transplant guidelines for further information. (to come)

2) **Brood stock number**

   a) Use as many spawners as possible (up to a third of the returning spawners; see **b**). The recommended minimum number may vary from more than 50 up to 200 per year (25 to 100 pairs) depending on the availability of the donor stock, historical size of the remnant stock, and/or carrying capacity of the receiving stream.
   b) Do not remove more than 30% of the remnant natural escapement for hatchery use (except if the stock is severely depressed, see item **d** below). Allow the remaining fish to spawn naturally.
   c) If you require eggs from only 10 females, but there are abundant fish:
      - Take fewer eggs from each of 25 or more females
      - Take extra eggs using more females, then remove the surplus during incubation or rearing

   d) If trying to rebuild an extremely depressed stock (e.g. < 100 spawners and below 5 – 20% of historical escapement), do it as quickly as possible. From a genetics perspective, it would be preferable to use all available spawnwers for broodstock. However, this strategy carries too much risk of catastrophic loss of the entire population. Instead use up to 50% of the returning spawners or a graduated collection plan that is scaled to return levels (to be developed and more detail provided)

e) Limit the escapement of hatchery-origin adults to less than or equal to 50% of the naturally spawning population (or escapement target for that stock) particularly if supplementing historically small stocks. The 50% rule was based on the DFO recommendations for hatcheries when rebuilding chinook and coho salmon in the Strait of Georgia. This strategy should moderate hatchery impact on the natural population.
f) If the stock is severely depressed, allow hatchery-origin adults to initially exceed 50% of the naturally spawning population. This should promote rapid stock rebuilding and prevent imminent extinction. At later rebuilding stages, hatchery-origin adults should not exceed 50% of the target escapement.
g) Replenish hatchery brood stock with wild stock infusion (e.g. 10% wild every other generation). This should help prevent genetic divergence of wild and hatchery stocks and reduce the risk of domestication of hatchery fish.

6.1.11. Brood stock collection

Collect brood stock in a stratified, random manner unless there are specific harvest strategy reasons:

a) Use fish from the entire run timing.
b) Do not collect broodstock on the basis of physical characteristics. Avoid artificial or intentional selection of spawners. Do not exclude small, unattractive or sexually precocious fish.
c) Use fish of all body sizes, including jacks. Use jacks proportional to their abundance in the total stock rather than their abundance in the river escapement, or if unknown at the rate of 10 – 15% of males. Each population has its optimum proportion of jacks. These precocious males may contain genetic material important for the long-term fitness of the population.
d) It may be appropriate to use disproportionately higher numbers of older salmon for spawning due to multiple age-fishery effects (specific guidelines will be developed for stock groups) *Do we still want this in cuz we never were able to provide guidelines.?*

6.2. Mating Practices

Genetic material is selected and passed on during spawning. Accordingly, appropriate mating strategies are critical for determining the genetic make-up of a population.

1. **If spawning more than 50 pairs, mate each female with an individual male.** This produces approximately similar family size for each male / female crossing, and helps maximize genetic diversity. Spawn all fully mature broodstock, without regard to age, size or other physical characteristics. Mate spawners randomly without bias toward observable traits. Avoid any selection during mating, especially where the goal is to produce fish that can successfully reproduce in the wild.

2. **If spawning fewer than 50 pairs, use a matrix spawning design.** Matrix spawning involves the crossing of gametes from a single male with the gametes from several individual females. This strategy allows the use of all broodstock even when the sex ratio is unequal and maximizes genetic combinations and each parent's contribution to the next generation. The basic concept is to divide eggs of each female into lots, each lot to be fertilized by a different male. In general, if males are more abundant than females, use a higher total number of males than females. If less, split the milt of each male among the same number of fractioned females, maintaining an overall one to one ratio. Table 1 (based on Eddy et al. 1996 reference to be added) outlines some examples of matrix design.

a) Select the appropriate matrix structure that will be workable throughout the entire spawning season based on the number of males and females in the broodstock and the sex ratio.

b) A minimum of 2 of the least available sex is recommended for each matrix. For a broodstock with an equal sex ratio, eggs from each female may be split into two approximately equal groups, and each group fertilized with sperm from a different male. For an unequal sex ration, use a 2 x 3) or 2 x 4 design (Table 1)

c) Use the same matrix design as much as possible but matrices may be adjusted at the end of each spawning day to compensate for an odd number of males or females left due to mortality or uneven sexual maturation,

3) **Avoid milt competition - do not pool milt.** This strategy avoids milt competition and ensures that each male makes an equal genetic contribution. Effectiveness of fertilization in pooled milt may differ considerably among males, resulting in a reduction in the effective number of breeders.

4) **Do NOT re-use males. If male infertility is a concern based on past experience or because you are dealing with a low number of eggs from a threatened stock use either of the following procedures:**
   a) Two males per female (recommended by R. Withler)
   b) Each male may be used twice but the same males should be added sequentially and only once per female

e.g.

```
Male 1  Male2        Male 2  Male 3      Male 3  Male 4      Male 4  Male 1        \
  \ /                 \      /              \     /             \ /
Female 1             Female 2             Female 3            Female 4
```

Table. 1 Spawning protocol scenarios and matrix selection (adopted from Eddy et al. 1996).

No. Fems No. Males	Sex Ratio	Proper Spawning Protocol	Examples of Different Broodstocks and Rationale for Selecting a Given Spawning Protocol
7. ≥100 F ≥100 M **8.** Large broodstock	1:1	No matrix used. Spawn 1x1. ***8.1.11.1.*** ***Fem X*** ***8.1.11.2.*** ***Male A*** ***A-X***	*8.1.11.3.* *8.1.11.4.* *150 Females +150 Males* - Large broodstock size -- sufficient to protect genetic diversity. - Even sex ratio allows 1x1 spawning. - No matrix is required. - Single pair mating is appropriate for this broodstock.
B <50 F <50 M Small broodstock	1:1	Use matrix. Spawn 2x2. ***8.1.11.5.*** ***Fem X*** ***Fem Y*** Male A A-X A-Y **B** **B-X** **B-Y**	*8.1.11.6.* *8.1.11.7.* *e.g. 40 Females + 40 Males* - Small broodstock size -- need matrix spawning to preserve or increase genetic diversity. - *Since have a small broodstock, include a minimum of 2 of the least available sex per matrix .* - Even sex ratio allows an even-sided matrix. - 2x2 matrix is appropriate for this broodstock.
D <50 F <50 M Small broodstock	Not 1:1	Use matrix. Matrix structure depends on sex ratio (usually not more than 2x4). (e.g., 2x3 matrix) *Fem X* *Fem Y* Male A A-X A-Y B B-X B-Y C C-X C-Y	***8.1.11.8.*** *8.1.11.9.* *20 Females + 35 Males* - Small broodstock size -- need matrix spawning to preserve or increase genetic diversity. - Also, uneven sex ratio requires matrix spawning to ensure that all broodstock are used. - Since the number of the least available sex (females) is well under 50, include a minimum of 2 females per matrix. - 2x3 matrix is appropriate for this broodstock.

Appendix 2 . – Enhancement Details (more material to be added if this section retained)
Enhancement Facility Locations

Table 1. Releases of juveniles from HEB hatcheries and manned channels in British Columbia Canada

Brood Year	Chinook	Chum		Coho		Pink		Sockeye	Cutthroat	Steelhead
		Unfed	Fed	Fry	Smolt	Unfed	Fed			
1977	13,620,370	52,127,027	1,904,625	2,073,819	2,984,462	31,029,220		191,179,000		127,810
1978	14,253,404	48,218,296	5,535,566	1,012,721	3,741,951	750		133,739,000		268,918
1979	16,379,080	69,550,228	9,191,947	3,691,819	4,963,264	26,145,904	358,639	200,179,521	682	310,292
1980	19,850,845	70,604,678	29,684,300	2,449,038	5,229,572	4,705,834	1,859,631	191,071,400	3,012	396,584
1981	17,563,349	50,709,042	68,980,710	7,311,022	4,889,684	33,113,088	492,034	170,814,370	9,732	711,136
1982	24,854,529	86,930,258	69,365,130	10,773,108	6,898,222	2,510,301	423,038	194,054,919	43,077	956,643
1983	29,374,066	83,266,067	85,579,589	8,930,958	13,585,563	27,341,916	1,521,896	128,964,333	33,970	1,400,810
1984	34,864,768	52,525,108	103,779,630	12,887,280	12,000,760	3,783,368	2,296,285	226,572,635	72,347	1,311,591
1985	42,736,623	41,614,811	102,464,677	8,852,842	9,720,856	25,432,597	5,057,021	157,434,930	109,045	1,501,462
1986	53,815,001	96,413,382	85,842,800	11,505,565	10,087,259	13,740,312	4,509,098	180,106,075	157,749	2,073,374
1987	63,631,981	101,859,170	75,979,591	8,066,239	9,534,951	43,696,480	4,807,689	122,471,589	179,737	1,896,518
1988	64,254,578	113,649,528	87,928,664	7,701,263	11,168,846	34,245,812	2,827,349	198,725,634	194,543	1,940,636
1989	63,254,499	83,288,150	92,214,006	9,637,576	11,705,728	48,240,457	2,884,163	206,752,792	164,027	1,840,159
1990	66,114,433	94,789,499	94,759,699	8,523,000	12,115,301	87,447,634	1,023,076	223,080,058	181,781	1,841,700
1991	59,326,978	79,481,997	96,839,355	9,421,861	10,700,087	54,216,640	1,584,525	227,135,058	178,076	1,642,679
1992	57,818,691	113,799,377	89,286,432	6,367,148	10,370,043	14,074,137	1,781,339	233,579,579	159,793	1,200,172
1993	50,834,933	101,859,532	93,399,435	6,477,421	10,735,588	36,840,352	1,576,168	179,045,418	154,936	1,061,360
1994	53,344,098	85,693,766	103,998,196	10,546,670	10,646,445	8,794,240	1,981,042	132,539,077	120,128	1,008,803
1995	45,205,507	33,590,212	87,665,283	8,200,503	11,311,460	32,476,878	2,001,615	77,980,811	128,428	960,635
1996	57,580,439	16,928,042	93,094,003	5,769,716	11,804,961	11,255,228	1,472,567	254,967,453	138,214	711,072
1997	49,797,448	45,470,998	104,038,311	5,212,183	11,558,341	34,741,905	1,640,496	84,204,632	85,676	995,164
1998	54,075,107	80,298,805	91,425,525	9,097,619	14,312,424	13,643,600	150,482	135,058,928	127,234	647,365
1999	54,199,157	18,858,989	78,593,285	8,139,340	12,721,759	11,505,870	3,198,637	148,912,649	105,283	670,415
2000	44,589,168	9,304,415	58,238,149	7,983,579	10,069,588	16,792,058	999,207	178,410,655	76,387	673,426

Policy Inconsistency Addendum - this section is for internal discussion only and not intended to be part of the guidelines
The Nov, 2000 discussion paper is the only version of the policy that been distributed to the public, although there have been high level presentations on the second draft.
Cultivated Species Language
A "cultivated species" was defined in draft 1 as "one that is artificially propagated completely or in part by continuing human intervention to increase production or meet other human needs". Aquaculture and enhancement were separated in the subsequent drafts because it was felt that the different objectives, risks and guidelines warranted separate discussion.

Definition of Wild Salmon
In Draft 2 : Where cultivated and wild salmon mingle, "the WSP applies to all wild salmon, including those mixed with enhanced salmon that are able to reproduce in natural surroundings"

From Draft 1 the policy recognizes "that wild salmon may continue to exist [within a population] even after intensive cultivation of a previously wild population" and that "wild salmon in cultivated populations warrant protection under the WSP to ensure the long-term viability of populations in natural surroundings." However, where transplants have occurred to establish populations "where the *species* did not occur naturally, the WSP *may* not afford similar protection." (italics added). On the Chilliwack river, there is a native spring run chinook stock and a transplanted fall run chinook stock. The fall run is the same *species* as the native stock so the issue of protection under the WSP for this stock could be argued either way. Note also that there where transplants have occurred to re-establish a previously existing species and run-timing, and the transplant is successful with on-going natural spawning, these fish will be afforded protection under the WSP.

These points may seem picayune but the question revolves around what it means to have the policy "apply" to wild salmon and what protection is afforded. If implies that protection or management of cultured stocks is not of concern.

Reference Points
Principle 2 *Wild* (italics mine) Pacific salmon will be managed and conserved as aggregates of local populations called conservation units.
Principle4 Fisheries will be managed to conserve *wild* (italics mine) salmon and optimize benefits.
"The WSP applies to all wild Pacific salmon including those mixed with cultivated (enhanced) population that are able to reproduce in natural surroundings".
(Second sentence in opening discussion paragraph for principles)

How will we deal with this when structuring reference points? Do we set reference points for only the wild fish in the population? This could leave us in the contrary position where we have chosen to use enhancement to rebuild a run with the intended strategy of having the enhanced fish return to the spawning ground to supplement the wild population but where we would not actually include enhanced fish when checking status against reference points. It also imposes a significant additional assessment cost as there is essentially a need to assess two different populations. In past rebuilding programs, both enhanced and wild fish were considered together for the target escapement but a limit was set on the proportion of enhanced fish that was to be in the return i.e. no more than 50% of the escapement target (there was no real scientific basis behind this limit, however). I've written some ways of including cultured fish into reference points in the guidelines documents.