Advice Related to Five "Big Picture" Science Issues for BC Salmon

Report on 6-7 November 2004 Workshop

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Executive Summary

The 11-13 June 2003 World Summit on Salmon clearly identified the need for collective action on several of the "Big Picture" issues related to Pacific Salmon. Following the Summit, there has been a series of meetings and conference calls to define the key issues and build a process for formulating and communicating scientific advice to decision makers. On 25 July 2003, a small group met to identify the priority scientific issues that should be the initial focus for further discussion. On 6-7 November 2003, a larger group of fisheries scientists met at Simon Fraser University (SFU). The goals for this meeting were to formulate some clear advice, recommendations, tasks and actions with respect to the following five key issues identified in the previous meetings:

- Core stock assessment programs
- Marine survival
- Freshwater fish habitat
- Role of Hatcheries
- Weak Stock Risk Assessment

The meeting was limited in size to provide an opportunity for focused discussion in small groups and a general review of each issue by all participants. The individuals invited to attend the SFU meeting included the senior scientists associated with these issues from the federal, provincial, and First Nation government agencies, universities, environmental groups and the private sector. It was recognized that our ultimate goal of providing clear scientific advice to decision makers on these five key issues would require more time and rigorous analysis that could be completed in a single meeting. The SFU meeting is just one step along the path to our ultimate goal and input from a broader spectrum of scientific expertise, resource users and decision makers should come at later stages in the process. The major recommendations resulting from this meeting were:

- A core stock assessment program must provide long-term indices of stock status, information on trends in marine survival, and data required to assess the effect of hatchery production on "wild" stocks. This program would provide the fundamental bases for future resource management and knowledge. A long-term funding for core stock assessment programs must be secured.

- The core stock assessment program must be defined by a group including fisheries scientists from government, university and the private sector and fisheries managers. Fiscal resources needed for assessment will always be limited in some manner, but a diversified approach to assigning responsibility and costs can assist government in this task. Core responsibility must remain within government for long-term protection of the information.

- There is a pressing need for research into the early marine survival of Pacific salmonids and the role of hatchery production in these processes. The biological effects of hatchery production in BC have not been adequately assessed and may have long term economic and biological consequences … particularly in the Strait of Georgia. This study could also be a major contributor to assess the impacts of climate change in the Pacific region.

- A risk assessment approach needs to be developed and applied in the decision making process used to evaluate alternative ways to collect the scientific information needed to manage and assess Canada's Pacific salmon stocks. Analysis of the costs, benefits and risks associated with alternative levels of scientific information must be included into the decision making process use to define program priorities.

- Habitat restoration and stewardship programs are widespread and important public involvement activities, but these activities can be costly and their effectiveness is seldom evaluated. Further, these programs are of limited benefit without appropriate management of water and other user impacts. Activities related to the protection and restoration of freshwater fish habitat must be coordinated and directed through a recovery plan approach, where priorities are clearly identified and processes are in place to ensure effective implementation and evaluation of these activities.

- Data management and communication standards must be developed and implemented for stock assessment data to facilitate information exchange between the groups participating in the delivery of these programs. Data system integration and accessability with Province of BC data systems has been an ongoing challenge and must be completed to facilitate comprehensive assessments of Pacific salmonid and their habitats.

INTRODUCTION

At the World Summit on Salmon eminent scientists from the Pacific and Atlantic met on 11-13 June 2003 in Vancouver BC to discuss the state of the World's salmon resources. Scattered among the large group of biological and social scientists were fishery managers, fishers, representatives from First Nation communities, and environmental groups. At times the discussion ranged far beyond the confines of the salmon resources to touch on the development and collapse of a wide variety of fisheries from across the World.

As with meetings of this kind, most of the time was spent describing problems and few solutions were discussed. But, now more than ever, in a World of expanding human populations and limited financial and biological resources, we need to get focused on defining and implementing solutions. We all share responsibility for the problems of the past and we need to find better ways of communicating our advice and ensuring that actions are undertaken to implement solutions. The scientists among us need to spend more time working together towards the formulation of clear and constructive advice for decision makers on the fundamental issues and less time debating theoretical arguments. The first step in this process is for individuals in each region to learn from our collective successes and failures and identify regional changes or activities required to implement real solutions.

On Canada's Pacific coast, the good news is that it is still not too late for most of our salmon stocks and significant strides have been made in recent years to reduce the intensity of our salmon fisheries and increase the public awareness of the need to protect and rebuild our wild salmon stocks and their habitats. One of the important changes required is for the scientific community to provide some clear direction and advice to the federal and provincial governments regarding the actions required. While the ability of humans to negatively impact the ecosystem upon which the salmon depend far exceeds our ability to protect and restore these systems, there are many activities that we do control. These activities include: harvest management (fishing methods, locations, regulations and enforcement), stock assessment, habitat protection and restoration activities, salmon enhancement and basic research. Clear scientific advice is needed regarding the potential benefits of better managing the intensity and complexity of salmon fisheries and forward-looking actions that could reduce the stress on salmon stocks and marine and freshwater habitats. A diverse group of widely respected scientists from regional universities, government agencies, environmental groups and private sector industry could and should be assembled to review our collective successes and failures relevant to salmon and provide clear advice and direction on the major activities and "big picture" issues. Advice could be delivered through the PFRCC to the highest levels of the federal, provincial and private sector agencies to assist them in their decisions regarding key salmon resource issues and allocation of their limited financial resources.

In the Pacific region, we are fortunate to have some of the world's best fisheries scientists and many of these have extensive experience with issues associated with Pacific salmon. On 25 July a group of scientists met in Sidney BC to discuss an initial set of priority scientific issues that require clear scientific advice and leadership from regional scientists. The participants at, or prior to, the 25 July meeting were: Sandy Argue, Dick Beamish, Karl English, Paul Kariya, Craig Orr, Randall Peterman, Brian Riddell, and Carl Walters. The 5 top priority scientific issues defined by this group are listed below:

a) Core stock assessment programs– the definition of the core programs required to assess the status of Pacific coast salmon stocks under different levels of fishing pressure (e.g. low, medium and high harvest rates). Core activities would include programs to monitor fishing mortality, spawning population sizes, indicator stocks to estimate marine survival and exploitation rates, and key environmental variables at appropriate spatial and temporal scales.

A core program of long-term monitoring and assessment is essential to any understanding of salmon dynamics, their status, and their ability to adjust to future conditions (e.g. climate change). A lack of such a core program and stable funding for such continues to be a serious threat to salmon and to those dependent on the salmon resource today and in the future. Core environmental monitoring in BC has been severely curtailed over the past two decades due to funding constraints. These cut-backs are now severely limiting our ability to assess impact of fisheries and climate change on salmon.

b) Marine survival - Our understanding of the mechanisms that determine marine survival for salmon must be improved, to minimize the potential for overharvesting and stock collapse in the future. Marine survival has emerged as the fundamental issue in Pacific salmon conservation in British Columbia. Major unexplained swings in marine survival have destabilized fisheries and exacerbated the challenges of fisheries management. During the 1990's, marine survival rates for Thompson River coho salmon and several other populations in British Columbia declined to the point where their continuing existence was threatened.

There are many benefits that would flow from an improved understanding of the factors influencing marine survival. Recent studies have already demonstrated the potential of such knowledge for generating substantial improvements in preseason forecasts of adult returns. These improvements can in turn lead to better fisheries planning and greater certainty for in-season management. In addition, this knowledge is essential for predicting the potential impact of climate change on Pacific salmon. An understanding of these mechanisms is also essential if we are to make informed decisions on both (i) strategic interventions to conserve threatened salmon populations and (ii) the use of hatcheries for augmenting fishing opportunities. There is also a strong public demand simply to know the cause of recent collapses and instabilities in fish populations. Past attempts to study marine survival have had limited success. Historically, the high costs, technical limitations and lack of scientific agreement on study designs have resulted in limited government support for studies of marine survival. However, a number of non-governmental groups have expressed keen interest in the marine survival issue but the level of support will depend on the degree of scientific consensus regarding the study objectives, technology and research plan for this assessment.

c) Protection and restoration of freshwater fish habitat - the PSF/PSEF has implemented a recovery planning approach which includes a process for setting priority activities both within and among watersheds and evaluating these activities against a specific set of goals for salmon recovery. A scientific review of this process would be helpful to provide clear direction to decision makers regarding the process used to manage, implement and evaluate future activities related to habitat protection and restoration in BC.

Substantial resources have been allocated to the restoration of freshwater fish habitat in the past. Current levels of support for these activities, while substantially reduced in BC, are still a significant component of the annual expenditures associated with salmon. Clear direction is needed to ensure that

available resources are used wisely and any future increases in restoration funding are directed towards proven and productive activities.

d) Future role of hatcheries - there are a number of key scientific issues associated with defining the future role of salmon hatcheries in the maintenance, enhancement and assessment of salmon stocks in BC. Some of these issues are currently being addressed through a review recently initiated by the PFRCC. In conjunction with the current review, clear and concise recommendations should be formulated for decision makers with a sound scientific basis for defining the future role of salmon hatcheries in BC.

Artificial enhancement is one of the most significant actions that humans have undertaken to develop and maintain salmon fisheries on the Pacific coast. In many instances, successes in artificial enhancement have resulted in significant impacts on non-enhanced stocks. As the public emphasis shifts from the production of salmon biomass to the maintenance of our wild stocks (i.e Species At Risk Act and Wild Salmon Policy), we must reassess the goals and objectives of hatchery operations. Can we learn how to manage hatchery production sustainably, or are hatcheries and wild salmon simply incompatible?

e) Weak stock risk assessment - clear scientific direction is required regarding the assessment of the risks to Pacific salmonid populations and resource users that are involved with the alternative approaches to salmon conservation. This scientific guidance is vital for decision makers and managers responsible for implementing the new Species At Risk Act and proposed Wild Salmon Policy.

Scientists have the tools to assess the risk associated with alternative approaches to salmon conservation. Clear guidance is required now to define how this process should proceed for both short-term and longer-term risk assessment efforts.

A two day meeting was held at Simon Fraser University (SFU) on 6-7 November 2003. The goals for this meeting were to formulate some clear advice, recommendations, tasks and actions with respect to the five "big picture" issues described above. The agenda for the meeting is provided in Appendix A. The meeting was limited in size to provide an opportunity for focused discussion in small groups and a general review of each issue by all participants. The individuals invited to attend included the senior scientists associate with these issues from Canadian government agencies, universities, environmental groups and the private sector. A list of invitees and participants is provided in Appendix B.

It was recognized that our ultimate goal of providing clear scientific advice to decision makers on these five key issues would require more time and rigorous analysis that could be completed in a single meeting. The SFU meeting was just one step along the path to our ultimate goal and input from a broader spectrum of scientific expertise, resource users and decision makers should come at later stages in the process. The meeting successfully initiated the discussion and progress towards our goal.

The following sections provide the products from each of the issue sub-groups and the general discussion. Each sub-group report includes a description of each "Big Picture" issue and the type of advice and recommendations required, along with a list of specific tasks and actions that must be undertaken.

CORE STOCK ASSESSMENT

The Federal government has a fiduciary responsibility per the Fisheries Act to manage the fisheries resources of Canada for the long-term benefit of all Canadians. The Oceans Act stipulates that all aquatic resource management is to be ecosystem-based and precautionary. The new Species at Risk Act established accountability for the protection of "wildlife species", the definition of which includes populations that are genetically or geographically isolated. For Pacific salmon this definition of species extends the provisions of SARA to many populations (stocks) of Pacific salmon.

The assessment program required to deliver on this mandate could be termed the "core assessment program". Such a program would necessarily include projects to identify the minimal set of populations or population aggregates that would be assessed. In general, "traditional" assessment programs involve the collection, processing and interpretation of data that pertains to spawner number (escapement), catch and other fishing mortality, and a variety of environmental and habitat variables that may assist in explaining or predicting variation in fish numbers or other attributes of the populations of interest to us.

There are increasing demands on the agencies involved in assessment to provide information and advice in an ecosystem context, to advise on the impacts of enhancement and aquaculture on the status of "wild" salmon, to provide explanations of the variability observed in salmon abundance and distribution and to advise resource managers on the probable impacts of fishing and habitat alteration. Furthermore the aspirations of First Nations and communities to steward their local resources are fueling pressure to provide information and advice at ever finer spatial scales and with more immediacy. These increasing demands for information and advice are occurring in a societal context of the Internet age where everything is expected to be on-line 24/7, understandable by interested but non-technical people and of course free. The agency context is one of increasing funding constraints and reduced staff. The unrestrained escalation in the quantity and complexity of information needs, resource demands and the uncertain support for science activities is a recipe for resource management failure.

The germane issue then can be characterized as how management agencies determine what the core assessment program is and not which data and programs are essential. The operational assessment plan could be readily designed by technical experts once the objectives are determined. The need then is for a rigorous process informed by science that first establishes objectives then allows informed decision making regarding the myriad of data needs and projects in the context of those objectives.

Definition of Stock Groupings and Management Objectives

The development and evaluation of alternative approaches for core stock assessment requires a detailed understanding of the range of management objectives and associated stock groupings. Most of our sub-group discussion was focused on defining the range of management objectives and examples of the associated core stock assessment needs. At the conservation level, the management objectives would be to minimize harvests and promote the recovery of depleted stock(s). The conservation unit may be a single stock such as Sakinaw sockeye or a group of stocks within a large geographic area (e.g. Interior Fraser coho). The core stock assessment program would be focused on monitoring indices of escapement, tracking trends in stock status and progress towards recovery. Above the conservation

level, management objectives would be focused on providing and assessing opportunities for harvesting. The target species, fishing methods, locations and intensity would determine the type of stock assessment programs required. The range of fisheries discussed included mixed-stock ocean fisheries, terminal mixed-stock fisheries and terminal surplus fisheries. Alternative approaches used for the different species and fishery types were discussed. These included: the Alaska and Northern BC approach for managing pink salmon fisheries, the contrasting approaches used for Nass, Skeena and Fraser sockeye, the PST requirements for chinook and coho and the provincial government approach for steelhead. It was generally agreed that scientific advice on the core stock assessment program would require rigorous analysis and evaluation of the costs, benefits and risks of each alternative against the management objectives. This evaluation should be conducted by a group including individuals with extensive experience with alternative approaches, program implementation, deliver options, costs, and risk assessment. The program development and evaluation process should be open to those agencies, First Nations and NGO's that could be involved with program delivery. In addition to formulating clear scientific advice, this approach would provide an opportunity to increase the awareness of the role of these core programs in providing the information needed for short-term management decisions and long-term understanding of salmon populations and their responses to climate change. There was also generally agreement that information from current and past stock assessment programs should be made more readily available in standardized formats to all agencies. Greater awareness of the core programs and their products is necessary to encourage annual improvements and long-term support for these activities.

Scientific advice or recommendations:

1. Conservation, harvest and long-term monitoring objectives need to be clearly defined and broadly accepted.
2. Stock assessment programs to address those objectives need to be developed by those agencies, First Nations and NGO's that could be involved in their delivery.
3. The stock assessment programs required to meet the objectives need to be rigorously evaluated.
4. The decision-making framework must include an evaluation of the costs, benefits and risks associated with the ability of alternative programs to meet objectives.
5. The development, acceptance and implementation of data management standards for existing stock assessment data must be expedited across agencies.

Specific tasks and actions:

A. A group, including fisheries scientists from government, university and the private sector, and fisheries managers, should be assigned the task of defining and evaluating alternative levels of core stock assessment effort associated with a range of objectives.
B. The goal should be to produce a clear and functional decision-making process that could be used to evaluate alternative stock assessment programs and provide scientific advice for decision makers.

Summary of Plenary Discussion

There was general support for the above recommendations, tasks and actions. There was broad recognition of the critical role that core stock assessment program play in providing the long-term data sets required to expand our understanding of salmon populations. Several individuals indicated that efforts to develop scientific advice regarding the core programs must be universal (i.e. not limit to a single region) and must be relevant at the project implementation level. There was also general support for the use of risk assessment in the evaluation process and the need for long-term programs that integrated core stock assessment needs with those required to evaluate hatchery production and monitor marine survival.

MARINE SURVIVAL

Marine survival has emerged as the fundamental issue in Pacific salmon conservation in British Columbia. Major unexplained swings in marine survival have destabilized fisheries and exacerbated the challenges of fisheries management. During the 1990's, marine survival rates for Thompson River coho salmon and several other populations in British Columbia declined to the point where their continuing existence was threatened.

There are many benefits that would flow from an improved understanding of the factors influencing marine survival. Recent studies have already demonstrated the potential of such knowledge for generating substantial improvements in preseason forecasts of adult returns. These improvements can in turn lead to better fisheries planning and greater certainty for in-season management. In addition, this knowledge is essential for predicting the potential impact of climate change on Pacific salmon.

An understanding of these mechanisms is also essential if we are to make informed decisions on both (i) strategic interventions to conserve threatened salmon populations and (ii) the use of hatcheries for augmenting fishing opportunities. There is also a strong public demand simply to know the cause of recent collapses and instabilities in fish populations.

Finally, Canada can foster good will with our neighbours around the North Pacific Ocean by contributing our share of research to this issue of common concern.

Monitoring and Research

The monitoring of indicator systems for the numbers of smolts leaving and adults returning provides critically important time series of estimates of marine survival. The few such series that are currently being generated are absolutely essential for monitoring trends in marine survival. In addition, this monitoring needs to be accompanied by research into the broad patterns of marine survival and the specific (potentially local) mechanisms that underlie these patterns.

Marine Life Stages

The marine phase of life for salmon can be divided into three components.

- **Adjustment to the marine environment:** This is generally regarded as a critically stressful passage, and is logistically the easiest marine stage to study.

- **First year of ocean life:** Scientists are beginning to understand general migration patterns, growth rates, feeding biology, etc. Survival during this first year, possibly especially in winter, may determine recent declines in marine survival.
- **Open ocean and return migration:** This is a poorly understood life stage and logistically the most difficult to study.

Recommended Research Priorities

Two broad areas of research are required. First, differences in marine survival and migration patterns among broad coast-wide areas need to be investigated. These studies are, by necessity, large-scale. Second, specific mechanisms leading to high marine mortality need to be examined. Since current evidence suggests that the first year of marine life is a critical period, research should be focussed on determining the location and timing of major mortality events and the occurrence of potential causes in that life stage. Emphasis should be on identifying key stressors and critical habitat areas. Two levels of geographic scale are possible. Studies like the proposed Pacific Ocean Shelf Tracking Project can provide valuable information on migration up the continental shelf. Other ecosystem studies need to be focused on smaller geographic areas, such as the studies in the Strait of Georgia, Barkley Sound, or Rivers Inlet.

Team Research

Given the complexity of the factors impacting marine survival, such research requires a team approach. The requisite research expertise and facilities will call for collaboration between agencies and across scientific disciplines.

Infrastructure Support

Research on marine survival calls for unique infrastructure. In particular, supervisors must commit to recognizing the contributions of scientists to a large research team in addition to independent contributions of an individual. In addition, funding support must cut across traditional agency and disciplinary domains – and at times even across international boundaries (The Bering Aleutian Salmon International Studies, a coordinated international study on marine survival salmon in the Bering Sea, on serves as a positive model of the benefits of such international collaboration.) Finally, there must be long-term commitments both from the top, to support the research, and from the bottom, to see the research through to a reasonable conclusion.

Specific Tasks and Actions:

A. Assign a group, including fisheries scientists from government, university, and the private sectors, and fisheries managers from each level of government (First Nations, provincial, and federal), the task of developing more specific proposals for implementation.

B. The group's goal should be to produce a clear integrated research proposal (on both broad and fine geographic scales) to be formally presented to government, industry, and non-governmental organizations for comment and formal response.

C. Specific issues to be addressed in a staged approach include:

  i. a coast-wide review of marine survival for species yet to be assessed, specifically including a search for consistencies over broad geographic regions;

  ii. an assessment of key knowledge gaps, both conceptual and geographic;

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  iii. studies focused on specific stressors and critical habitats for salmon in the first year of marine life;

  iv. a summary of current understanding of the physical factors that affect marine productivity of coastal British Columbia waters and the marine survival of juvenile Pacific salmon to these physical changes;

  v. a summary of our current knowledge of how these factors (and responses) are impacted by changes in climate and ocean conditions; and

  vi. the establishment and maintenance of long-term physical and biological data bases.

Summary of Plenary Discussion

1. It would help to identify key ecosystem interactions and potential stressors, such as predation, food availability, etc.

2. There was a suggestion that more experiments be considered, that there was perhaps too much emphasis on monitoring.

3. The potential value of the research is not adequately justified in the proposal as it stands. Potential impacts of aquaculture, hatchery enhancement, and oil and gas need to be highlighted as potential applications and ways of generating support. Specific proposals aimed at addressing these issues need to be developed. In general, a closer tie to specific management issues should be made.

4. The value of the staged approach of looking at spatial patterns first was stressed, and some thought that this was sufficient.

5. Some felt that the value of understanding mechanisms may be low relative to the costs of the research. This has led some participants to argue for restricting activity to monitoring overall survival patterns which would then be used to develop management actions in response to these observations without looking into the causes. Others felt equally strongly that the underlying mechanisms driving these patterns needed to be studied.

FRESHWATER FISH HABITAT

Freshwater salmon habitat is vital to the future of Pacific salmon. At the June 2003 world salmon summit, Robert Lackey summarized the major threats to freshwater salmon habitat as:

- Freshwater and estuarine habitat alteration due to urbanizing, farming, logging, and ranching;

- Dams built and operated for electricity generation, flood control, irrigation, and other purposes;

- Water withdrawals for agricultural, municipal, or commercial requirements;

- Stream and river channel alteration, diking, and riparian corridor modification; and

- Reduction in the annual replenishment of nutrients from decomposing, spawned-out salmon

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These five bullets accurately reflect the main threats to salmon habitat in British Columbia, and should thus be the focus of any plan designed to protect and/or restore salmon habitat. Scientists also agree that protection of habitat is more effective than restoration in terms of both costs and biological effectiveness, and thus should have a higher priority than restoration in planning programs. Furthermore, returns on habitat protection and restoration efforts are subject to sociopolitical considerations. Lackey maintains that any policy or plan targeted to restore wild salmon runs must at least implicitly respond to four core drivers or that plan will fail. The core policy drivers are the:

1. Economic rules of the game, especially the international and domestic drive for economic efficiency through market globalization, which tend to work against increasing the numbers of wild salmon;

2. Increasing scarcity and competition for key natural resources, especially for high quality water;

3. Rapidly increasing numbers of humans in the region and meeting their basic needs; and

4. Individual and collective life style choices and priorities.

If, as Lackey says, effecting any change in the long-term downward trend for wild salmon is futile in the absence of shifts in the core drivers, scientific advice on habitat restoration and protection is most likely to be successful if linked to social and economic drivers.

The recovery planning approach recently adopted by the PSF/PSEF is attempting to build on some of the social and economic links between the protection and restoration of fish habitat and other activities in a watershed. The recovery plans prepared to date have been effective at focusing and guiding activities at the local level and encouraging the participation and support of local landowners, community groups, First Nations and businesses. The first steps towards addressing the core policy drivers are being taken but much more work remains to be done.

Advice and Recommendations

Habitat Restoration
1. Habitat restoration initiatives should occur within the context of an overall watershed/ ecosystem/community recovery planning process;
2. These recovery plan processes may contain specific objectives for restoration and protection of fish habitat that reflect linked scientific, social and economic interests;
3. There is a need for directed research to identify the basis and limits for habitat restoration and production bottlenecks;
4. There is a need for consensus and coordination on appropriate program monitoring and evaluation strategies to ensure that limited resources are used wisely;
5. Governments should work with the private sector and First Nations to enhance existing stable, long-term funding mechanisms;

Habitat Protection
1. Protection of salmonid habitats is crucial to the maintenance of biodiversity and resilience, recovery and protection of species at risk, and protection of weak stocks (sustainable fisheries);
2. Scientists must improve communications about our understanding of critical habitat requirements, and make clear recommendations regarding habitat protection priorities relative to watershed interests.

Tasks and Actions:

Habitat Restoration
1. Establish a mechanism for community review of salmon recovery plans;
2. Establish a research initiative to address production bottlenecks, limits to recovery, and appropriate (cost-effective) monitoring and evaluation strategies;
3. Develop a mechanism for a coordinated funding approach to habitat restoration and species recovery (e.g. a fund manger's group);
4. Incorporate recent learning on water flow restoration gained from BC Hydro's water use planning program; and
5. Encourage the development of a national water strategy.

Habitat Protection
A process needs to be established to acquire the information required to define the habitat requirements for:
1. Biodiversity and resilience goals for salmonids and their ecosystems;
2. Recovery and protection of species at risk; and
3. Protection of weak stocks; and sustainable fisheries.

ROLE OF HATCHERIES

Artificial enhancement involves a wide array of program types and is one of the most significant actions that humans have undertaken to maintain salmon fisheries on the Pacific coast. Canada has invested heavily in major hatcheries, spawning channels, habitat restoration, and smaller projects to increase salmon production but often with mixed results. In many instances, artificial production has affected non-enhanced stocks through mixed-stock fishery management and biological interactions (potentially ecological, genetic, or disease). The economic, social, and biological benefits of these programs have been increasingly debated over the past 20 years. This debate is being exacerbated through increasing competition for funds, including our need to inform the debate through improved knowledge of the interactions. We do know though that enhanced production cannot be considered independently of the natural populations or ecosystems, that genetic change within intensive culture is inevitable, that simply producing more juveniles does not guarantee continued fisheries, and that concerns for biological interactions with wild stocks has not been adequately researched.

As awareness of salmon conservation issues (i.e., Species At Risk Act and Wild Salmon Policy) increase, there is a need to re-assess the goals and objectives of artificial enhancement programs. Enhancement projects for local Pacific salmon populations have become part of the social fabric in

communities of British Columbia. Any changes to program should expect resistance unless supported by sound science and assessments of impacts on local communities. For example, is production of salmon in hatcheries sustainable and can the interactions between hatchery and naturally-produced salmon be managed with acceptable risk? Can enhancement be modified to provide cost-effective benefits and how will these be assessed?

In conjunction with the current PFRCC review of hatchery production, a sound scientific basis is needed to evaluate future roles of salmon hatcheries and other enhancement activities in BC. Human intervention increases the risk of effects on natural populations and has frequently been the focus of this debate.

Scientific advice or recommendations:

Advice and recommendations should be framed within the roles that enhancement is intended to fulfill. Within these roles, there are issues that have frequently been identified as potential sources of interactions with natural populations and that need to be assessed to fully benefit from natural and artificial production. Of greatest concern in the debate described above are programs with human intervention in spawning and/or controlled rearing of juveniles. The size or scale of these projects may vary significantly but sources of concern for these projects depend on the relative size of the cultured versus natural population, the cultivation history of the stock, and local environmental conditions. Consequently, a feature of studies on the interaction of cultured and natural populations is that results are frequently site specific and will required replication.

The following matrix compares some "generic" roles of culture programs with three broad types of interactions that are commonly discussed. For each role, the level of risk associated with each type of interaction is ranked and any current issues identified.

Roles	Potential Interactions			Comments
	Mixed-stock fisheries	Ecological	Genetic	
Fisheries Augmentation (increase production)	primary concern fisheries exceed sustainable harvest rate for natural populations	2nd rank, competition and over-fishing may lead to replacement of natural production	3rd rank, intensive brood stock/culture increases risk of domestication	Major concern for development of mass-mark selective fisheries
Supplementation (Augment natural spawners)	3rd rank, assumes reduced impacts for rebuilding of natural stock	Primary concern, deliberately mix with natural populations (fw, marine, spawning interactions)	2nd rank, should involve local source brood stock & reduced domestication affects	Highly dependent on habitat capacity for added juveniles and spawners
Recovery or Conservation (preservation of depressed popn.)	3rd rank, assumes much reduced impacts for rebuilding of	2nd rank, varies with methods for re-introduction, but any severely	Primary concern, intensive genetic management, cultured stock likely	Includes captive brood programs, requires effective introduction of

		natural stock	depressed popn at greater risk	to dominate numerically	cultured genes back into natural popn.
Large scale produc tion.	Stock Assessment and Management Information	Source of concern varies with relative populations. Genetic population used in Release size small management of fisheries.	similar to Supplementation programs but size of cultured versus natural risk should be reduced assuming local culture and no brood stock maintained. enough that this role should not influence		Assessment conducted within all major hatchery programs but may also involve small scale hatcheries just for marking indicator stocks (eg. Dome Cr Chinook)

Small scale production.

Within each possible source of interactions there are several information requirements for assessment and/or topics that could be researched to fully investigate these concerns. A minimum outline of the essential topics include:

Production assessment and fishery management information	Ecological Interactions (impacts on natural stock productivity)	Genetic Interactions (impacts depend on brood stock protocols and relative size of cultured and wild stocks)
- Stock identification in catch (typically via coded-wire tags) - Enumeration of spawning escapements - Exploitation rates and patterns - Marine survival rate by brood year - A comparative basis with local natural populations … reference stocks for monitoring	- predator responses - food competition (freshwater & marine) - freshwater residualism (food & space) - spawning competition - inter-specific competition and predation	- Relative reproductive fitness (productivity) of cultured fish in the wild? - How quickly does genetic change occur, both during domestication & reversal in wild? - What is the value of genetic diversity … productivity and survival determinants?

Unfortunately, with the exception of assessment programs conducted to assess cultured production, there has been minimal investment in the research necessary to understand and manage the above

sources of interactions. The commitment to coded-wire tag (or other external marks) assessment of cultured (usually hatchery) production has been a strength of the Salmonid Enhancement Program. These programs provided invaluable information for the Regional management of hatchery and natural chinook, coho salmon and, to a lesser extent, chum salmon.

Items to be emphasized in our advice:
1. The long-standing commitment to coded-wire tag assessment of hatchery production is becoming severely compromised by reduced funding and the development of mass-mark selective fisheries. This loss of this information would seriously limit assessments of hatchery and wild salmon production and fishery impacts, and the information critical to understanding annual variations in the marine survival of salmon.
2. The development of mass-mark selective fisheries was designed to reduce harvest impacts on natural populations while providing fishing opportunities on cultured fish. The program would not, however, address any of the other concerns for ecological or genetic interactions.
3. Assessment of hatchery interactions with local natural populations has received much less attention or research, relative to assessments of culture techniques and production. Critical questions of ecological and genetic effects have not been adequately studied.
4. With our current level of knowledge concerning potential interactions, we should anticipate extensive debates concerning any plan to modify use and/or abundance of cultured salmon.
5. There is an increasing demand for advice on the genetic conservation and recovery of severely depressed natural populations of salmon. At present, we have very limited ability to advice on these strategies, but we do have the facilities and knowledge in the Department and local universities to undertake the necessary research.

Recommendations:
1. Given the limited past research on ecological interactions, a significant experimental management study should be undertaken to assess large scale changes in enhanced production (potentially within the Strait of Georgia for integration with other research topics discussed). Monitoring of production variation in cultured and wild control (reference) streams must use methods with comparable accuracy and biological sampling of returns in each stream.
2. With the capability now of DNA analysis to assess reproductive fitness of individuals, a set of research programs should assess variation between individuals in hatchery and wild populations, the fitness of cultured salmon spawning in natural populations, and the possible impact of cultured salmon the productivity of these natural populations.
3. Depending on available research funding, consideration should be given to an integrated SEP and Science (with local universities) program to develop a research oriented hatchery.
4. Loss of the coded-wire tag program would be an unacceptable loss of information. Any change to the program requires careful examination and proceed in phases dependent upon research and development.
5. Research and potential changes to culture programs must be clearly communicated to others involved with enhancement programs, resource users, and to the broader community of British Columbia.

In recognition that the Salmonid Enhancement Project has been an experiment without a control, assessment needs to be conducted through knowledge of the underlying processes. In other words, the harvest and escapement of wild systems, exclusive of enhanced production, needs to be estimated to

allow for quantitative impact assessments. Computer models could provide a means to integrate information on processes and structure appropriate experimental or production designs.

"WEAK STOCK" RISK ASSESSMENT

Canada has signed various biodiversity agreements and there is general concern about maintaining biological diversity. For example, management agencies are facing more difficult decisions due to concerns about low-abundance and/or low-productivity Pacific salmon stocks ("weak stocks"). To make well-informed tradeoff decisions, fisheries managers and other decision makers need good information about the risks that such stocks face. Stock assessments and risk assessments produce this information. Risks arise from uncertainties about how the future will unfold (e.g. climatic conditions; outbreaks of disease or parasites) and uncertainties about how the ecological system actually functions (as opposed to how we model it), particularly when stocks are at low abundance.

A major issue is how to define the appropriate spatial scale for units of concern for the risk assessment (e.g. broad regional populations, local groups of a few spawners, or something in between?). Another significant challenge is to estimate risks from various activities such as harvesting, enhancement, and habitat alteration given that we often have little information on those activities for a specific stock in question. How much can we legitimately extrapolate from lessons learned about these activities on similar stocks elsewhere? Quantitative risk assessment procedures exist but the lack of good data often necessitates simpler approaches that only qualitatively estimate risks from various activities. Where sufficient data exist to do a quantitative risk assessment, various assessors may apply different methods, unnecessarily creating confusion among decision makers and leading to uninformed decision making.

Another challenge deals with communicating to others the risk assessment followed and the results. Scientists usually do not report their risk assessments and stock assessments in a manner that is accessible to other people, which impedes good decision making. A related issue is that many decision makers and stakeholders do not understand the importance of maintaining weak salmon stocks.

The provision of scientific advice on weak stocks is perhaps best described in the context of a Risk Assessment Framework. Such a framework is applicable to a wide range of situations, including (1) fishery management of stocks in general, including weak or threatened stocks, (2) Species at Risk, and (3) recovery planning. A timely and properly applied Risk Assessment Framework will move decision-making on salmon away from a reactionary process to one based more on proactive planning.

To avoid the pitfalls of mis-communication and uninformed decision-making, risk assessment <u>must</u> be conducted in an all-inclusive manner involving all parties with an interest in the stock group of concern. These parties include decision makers, harvesters, First Nations, NGOs, others affecting the resource, and scientists.

Scientific Recommendations

1. The group that is doing the risk assessment should clearly define what it means by "risk" and "risk assessment".
2. Develop mechanisms and procedures (programs, manuals, applied training, etc.) to provide guidance, ensure continuity, and increase capacity to perform risk assessments, regardless of whether they are within SARA recovery planning processes, fisheries management, Pacific Salmon Foundation recovery planning, or other activities. This might include steps in the table below.
3. Establish a core group of risk assessment specialists to provide continuity and integration for risk assessments carried out in different situations.
4. To learn from risk assessments done elsewhere, we need a literature review of previous work on risk assessment procedures in other regions related to fish, as well as other taxonomic groups (e.g. U.S. EPA's 1998 "Framework for Risk Assessment"; DFO's 2003 "Recovery Planning Guidelines"; SARA Checklist; Environment Canada's Guidelines for Risk Assessment).
5. Articulate long-term management objectives of decision makers for the stock unit of concern.
6. Generate and maintain long term, standardized, geographically referenced integrated databases such as the BC watershed atlas, Salmon Escapement Data System, in a way that allows cross-linkages among them.
7. Identify the various scales of "stock groupings" (SG) to be considered in a risk assessment and the repercussions of each. For example, the scale of aggregation of fish groups can range from large regional management units to small spawning aggregates. Results of risk assessments that estimate at one scale the probability of losing a given "stock group" will be different from those at another scale. This process of identifying the appropriate spatial scale for the units of risk assessment must involve decision-makers because the choice is set by the policy context and also managers need to understand the rationale behind choosing the level of analysis.
8. Compile evidence to demonstrate the value of maintaining biological diversity including, for example, resilience of the ecosystem to future change (e.g. climate), built-in redundancy of ecological functions, genetic diversity, reduced social costs (e.g. fewer fishery closures). Convey to others why an economic value cannot be placed on biological diversity.
9. Develop clear management objectives for specific "stock groupings" (SGs).
10. During the risk assessment process, develop the materials necessary to clearly communicate with a wide audience, including decision makers, peers, stakeholders, public.
11. Develop and implement strategies to close the gap between the estimates of risk and the perception of risk,
12. Continuous and additional funding will be required to apply risk assessment to fishery management, weak stock management, and recovery planning.

Draft Steps in a General Risk Assessment Framework

We envision that risk assessment might proceed at two levels of scale and detail (regional and stock-group levels).

REGIONAL OVERVIEW

An essential requirement for this first overview step is to have appropriate databases, as noted above.

1. Identify alternative "stock" groupings (SG). (See figure below.)
2. Identify management objectives for each SG.
3. Identify threats for each SG (harvests, logging, other disturbances).
4. Identify biological vulnerability for each SG, i.e. how close the SG currently is to some state that is a major concern.
5. Assign level of risk (biological, economic, social) for all SGs.
6. Prioritize SG for research, recovery, exploitation, etc. based on management objectives.

As noted above, it is critical that this Regional Overview be done collectively by scientists, NGOs, regional stakeholders and decision-makers.

RISK ASSESSMENT SPECIFIC TO THE STOCK GROUPING IDENTIFIED

The extent of analysis in each of the steps below depends on the available data. The following table describes the steps in a risk assessment process that is specific to a particular stock grouping. The table illustrates some examples of types of analyses that should be conducted for "data-poor" and "data-rich" situations. At a minimum, all steps of the risk assessment should be carried out at the level indicated under "data-poor" situations. Ideally, we should aim to carry them out as indicated under the "data-rich" column. These steps of risk assessment must be applied iteratively, rather than moving linearly through the list only once.

Steps of risk assessment	Data-Poor Situations *(examples only)*	Data-Rich Situations *(examples only)*
1. Clarify long-term management objectives (preservation, recovery, exploitation rate, ...)	Create harvestable surplus, recovery of population	Create harvestable surplus, recovery of population
2. Identify threats and/or constraints on actions (past, current, future)	List threats	Quantitative data (e.g. water flows, harvest rate) to estimate impacts on populations
3. Describe biological system (status, productivity,...)	Indices of abundance, life history traits	Escapement, capacity, productivity estimates, population traits, processes affecting popul. dynamics
4. Identify indicators of achieving goals (e.g. abundance, geographic range, productivity, harvest rate, de-listing criteria (for SARA), population thresholds)	Presence/absence, abundance indices, condition factors, productivity, trend analysis, changes in range of geographic distribution	Quantitative (escapement relative to goal, percent of range occupied); e.g. $Pr(Spawners > Goal\ by\ Yr_{20}) > 0.7$
5. Identify actions available to	Diagrams of pathways of	Quantitatively define range of

reduce threats, achieve goals	effects	actions to consider
6. Consider full set of uncertainties about ecological, economic, and social responses to different actions	Qualitatively describe uncertainties *(in economic and social systems too, not just the ecological system!)*	*Quanti*tatively describe uncertainties *(in economic and social systems too, not just the ecological system!*
7. Apply tools for estimating risks and other relevant indicators	Habitat modeling, draw lessons from other systems	Conduct quantitative stochastic population modeling to estimate outcomes of actions and system dynamics; explicitly represent uncertainties; apply sensitivity analysis, decision analysis
8. Communicate methods and results of risk assessment to appropriate audiences	Clearly document what is known and methods used	Clearly document what is known and methods used; for extensive analyses, use a hierarchical information package that allows readers with different backgrounds to use it efficiently.
9. Design monitoring program to evaluate success or failure	Trend analysis, changes in geographic range	Before and After, Control / Impact (BACI)

APPENDIX A

CLEAR SCIENTIFIC ADVICE ON "BIG PICTURE" ISSUES
Simon Fraser University – Halpern Centre
6-7 November 2003 - Agenda

Day 1

8:30-8:45	Welcome – Why we are here. – Paul Kariya
8:45-9:15	Workshop goals, process and products – Karl English Providing scientific advice to decision makers – Art Tautz
9:15-10:30	Introduction to the selected "big picture" issues 　　　Core stock assessment – Karl English 　　　Marine Survival – Dick Beamish/Rick Routledge 　　　Freshwater Fish Habitat – Craig Orr 　　　Role of Hatcheries – Brian Riddell 　　　Weak Stock Management – Randall Peterman
10:30	Break into sub-groups
10:45-12:00	Initiate discussions in work groups – goals, process and products
12:00-1:00	Lunch
1:00 – 1:45	Whole Group – Feedback on goals, process and products
1:45 – 4:30	Sub-groups – prepare products
Evening	Review and edit draft products

Day 2

8:30-9:30	Sub-group review and discussion of draft products
9:30-12:00	Presentations and discussion of sub-group findings and products 　　　Core stock assessment 　　　Marine Survival 　　　Freshwater Fish Habitat
12:00-1:00	Lunch
1:00-2:00	Presentations and discussion of sub-group findings and products - continued 　　　Role of Hatcheries 　　　Weak Stock Management
2:00-3:00	General discussion and conclusions
3:00	Where we go from here - next steps

APPENDIX B - List of Participants and Issue Groups

	Core Stock Assessment	Marine Survival	Freshwater Fish Habitat	Role of Hatcheries	Weak Stock Risk Assess.
Sandy Argue				na	
Dick Beamish		C			
Karl English	C				
Patricia Gallaugher					
Paul Kariya					
Craig Orr			C		
Randall Peterman					C
Brian Riddell				C	
Carl Walters		na			
Rick Routledge		C			
Rich Chapple				C	
Angus MacKay			C		
Mike Bradford					C
Al Cass					na
Carol Cross				C	
Michael Crowe			C		
Matt Foy			C		
Blair Holtby	C				
Gary Logan				na	
Dave Peacock	C				
Neil Schubert	C				
Mel Sheng			na		
D.Welch / M.Trudel		C			
Chris Wood					na
Bob Bocking					C
Don Hall			C		
Russ Jones		C			
Mike Staley				C	
Ken Wilson	na				
Ted Down			na		
Michael Healey		na			
Art Tautz	C				
Eric Parkinson					C
Bruce Ward		C			
Bill Gazey				C	
Otto Langer			C		
Mike Lapointe	C				

C = confirmed, na = not available