Fisheries and Oceans Canada | Pêches et Océans Canada

WILD SALMON POLICY
DISCUSSION PAPER

A New Direction:

The Fifth in a Series of Papers from Fisheries and Oceans Canada

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Canada

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EXECUTIVE SUMMARY

On October 14, 1998, the Minister of Fisheries and Oceans Canada established a *New Direction for Canada's Pacific Salmon Fisheries*. The New Direction focuses on conservation, sustainable use, and improved decision making. Its general principles set out a broad policy framework under which specific operational policies and guidelines for managing Pacific salmon would be developed. The Wild Salmon Policy (WSP) is one of a series of papers that specifies these operational policies and guidelines.

Wild Pacific salmon are affected by fisheries and other human activities that degrade salmon habitat. Annual environmental variation and climate change also affect production. In this unpredictable environment, with so many demands on the resource, decisions about fishing, habitat development, and salmon cultivation must be made carefully to ensure sustainable social and economic benefits for future generations of Canadians. The WSP provides an explicit conservation framework to conserve the genetic diversity in wild Pacific salmon and to protect their habitat from irreversible depletion.

Fisheries and Oceans Canada has the responsibility and legislative authority under the federal *Fisheries Act* to ensure that Pacific salmon and their habitat are protected. At the same time, other levels of government have the legislative jurisdiction to control activities on land that can adversely affect fish habitat. Over the longer term, fish habitat will be maintained only if stewardship is endorsed by all elements of society. Pacific salmon are also caught in fisheries that occur beyond Canada's national boundaries. The 1999 renewal of the Pacific Salmon Treaty with the United States provides greater assurance that conservation requirements will be met.

The primary goal of the WSP, consistent with the United Nations *Convention on Biological Diversity*, is to ensure the long-term viability of Pacific salmon populations in natural surroundings and the maintenance of fish habitat for all life stages for the sustainable benefit of the people of Canada. Accordingly, the WSP applies to all wild Pacific salmon including those mixed with cultivated (enhanced) populations that are able to reproduce in natural

surroundings. The following six principles will guide decisions and activities that affect the conservation of wild Pacific salmon.

Wild Salmon Principle One: ***Wild Pacific salmon will be conserved by maintaining diversity of local populations and their habitats.***
The preservation of the quality and diversity of salmon habitat, and its accessibility to salmon, should be the primary consideration of any strategy to conserve wild Pacific salmon. Implementation of Principle 1 will be guided by the *Policy for the Management of Fish Habitat*.

Wild Salmon Principle Two: ***Wild Pacific salmon will be managed and conserved as aggregates of local populations called conservation units.***
The goal of maximizing sustainable benefits from local populations must be balanced against the cost and practicality of doing so. Thousands of local populations exist in British Columbia alone and it is logistically impossible to manage each population individually. However, it should be possible to conserve the genetic diversity of local populations by managing ***conservation units***, defined as aggregates of closely related populations with similar productivity and vulnerability to fisheries.

Wild Salmon Principle Three: ***Minimum and target levels of abundance will be determined for each conservation unit.***
The precautionary approach to fisheries management requires that operational targets and constraints be expressed in measurable terms. Accordingly, a ***limit reference point*** (LRP) and one or more ***target reference points*** (TRP) will be specified for each conservation unit based on estimates of productive capacity. A total abundance above the TRP is in the "target zone". A total abundance below the TRP but above the LRP implies that the conservation unit is secure but requires "rebuilding" to optimize sustainable production for future generations. A total abundance below the LRP implies a stock "collapse" and indicates that the long-term viability of the conservation unit is at risk.

Wild Salmon Principle Four: ***Fisheries will be managed to conserve wild salmon and optimize sustainable benefits.***
Management plans should be specified for each conservation unit through pre-season consultation. These plans should include options based on a

range of abundance forecasts or in-season estimates for the conservation unit. Objectives and corresponding harvest will be developed in consultation with First Nations and stakeholders, and in accordance with other Departmental policies such as *An Allocation Policy for Pacific Salmon* released in October 1999.

Wild Salmon Principle Five: ***Salmon cultivation techniques may be used in strategic intervention to preserve populations at greatest risk of extirpation.***
Genetic diversity and fitness are threatened by chance events whenever local population abundance declines to critically low levels. Technologies such as fish culture, broodstock rearing (aquaculture), and gene banking may be used strategically to reduce loss of genetic diversity at critically low abundance. However, strict guidelines are required to ensure that these technologies do not adversely and irreversibly affect the long-term productivity of the conservation unit.

Wild Salmon Principle Six: ***For specified conservation units, when genetic diversity and long term viability may be affected, conservation of wild salmon populations will take precedence over other production objectives involving cultivated salmon.***
Inevitably, some forms of salmon cultivation will lead to ecological or genetic interactions between wild and cultivated salmon. These interactions may affect the genetic diversity and long-term viability of wild salmon. Accordingly, all proposals involving salmon cultivation must be reviewed carefully to minimize adverse effects on natural production.

Over the next six months, Fisheries and Oceans Canada will convene facilitated meetings with representatives of First Nations, recreational and commercial fishing sector representatives, the aquaculture industry, environmental and stewardship groups, and other interested parties. Consultations will be co-ordinated with other planned consultations on the future of the Salmon Enhancement Program. Bilateral consultations will be undertaken with First Nations, in order to meet the fiduciary responsibilities of the Crown. There will also be consultations and discussions with the Province of British Columbia and the Pacific Fisheries Resource Conservation

Council. A final policy statement is anticipated for release late in 2000 following the consultation period.

Copies of this document are available on the internet at http://www-comm.pac.dfo-mpo.gc.ca/wsp-sep-consult and at Fisheries and Oceans Canada offices throughout BC and the Yukon. Comments from all interested parties are welcome and can be provided through e-mail to wsp.sep.consult@pac.dfo-mpo.gc.ca
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INTRODUCTION

> *"Pacific salmon have long served as food for First Nations and are a source of their cultural identity; they provide jobs and income for Canadians, businesses and coastal communities; they provide recreation and enhance our quality of life; and serve as a measure of our environmental health and well being. Pacific salmon help define who we are and where we live. They are our heritage and our responsibility; they must also be our legacy.[1]"*

To preserve this legacy, the *Wild Salmon Policy* (WSP) provides guidelines for conserving the long-term viability of Pacific salmon populations, their natural habitats, and the resulting production. Wild Pacific salmon are affected by fisheries and other human activities that degrade salmon habitat. Annual environmental variation and climate change also affect production. In this unpredictable environment, with so many demands on the resource, decisions about fishing, habitat development, and salmon cultivation must be made carefully to ensure sustainable social and economic benefits for future generations of Canadians. An explicit conservation framework is needed to conserve the genetic diversity in wild Pacific salmon and to protect their habitat from irreversible depletion.

Wild salmon require "high quality" freshwater and marine habitats to survive, and are often considered to be an indicator of ecosystem health. To maintain a suitable environment for wild salmon, humans must restrict their activities in that environment. Conflicts inevitably arise when other uses of salmon habitat promise large economic benefits (e.g., hydroelectric power generation, forestry, etc.). Societies throughout the world have dealt with this inherent conflict, but often unsuccessfully. In much of Japan, wild salmon and their natural habitat have virtually disappeared; the commercially important species, pink and chum salmon, are maintained by artificial propagation in hatcheries. The Japanese have accepted the risk that the long-term viability of pink and chum salmon in Japan depends on the success of hatchery programs. In the USA, the decision to use salmon habitat to generate hydroelectric power is now seen largely as a failure in salmon conservation. Enormous costs have been incurred attempting to preserve the

[1] A New Direction for Canada's Pacific Salmon Fisheries, Statement by Minister of Fisheries and Oceans, Canada, 14 October 1998

remaining populations in the Columbia River and other watersheds. Similarly, after decades of damming rivers and relying on hatchery production to support their Atlantic salmon fishery, Scandinavian and Baltic countries now recognize the importance of wild salmon conservation and have implemented strong policies in support of conservation. Canadians can take pride in their approach to managing Pacific salmon resources. Canada has restricted hydroelectric development on large rivers used by anadromous fishes and has been more careful than other nations in augmenting natural production through large-scale hatchery supplementation, ocean ranching and aquaculture.

On October 14, 1998, the Minister of Fisheries and Oceans Canada established a *New Direction for Canada's Pacific Salmon Fisheries*. The New Direction focuses on conservation, sustainable use, and improved decision making. Its general principles set out a broad policy framework under which specific operational policies and guidelines for managing Pacific salmon would be developed. The challenge for Canadians is to determine how wild salmon will be part of the New Direction and to do what must be done to make it happen. The WSP describes the approach that Fisheries and Oceans Canada will follow to conserve wild Pacific salmon for present and future generations. It contains: (1) background information about Canada's international commitments to conserve the diversity of the world's biological resources; (2) a description of the major factors that affect the long-term viability of wild Pacific salmon; (3) principles to guide the conservation and management of wild Pacific salmon; and (4) a consultation process.

JURISDICTION

Pacific salmon are anadromous fishes. They begin life in fresh water, migrate to sea to feed, and return to spawn in the lake or stream where they hatched. This anadromous life history is a natural adaptation to maximizing survival in both fresh water and the ocean. Fisheries and Oceans Canada has the responsibility and legislative authority under the federal *Fisheries Act* to ensure that Pacific salmon and their habitat are protected. At the same time, other levels of government have the legislative jurisdiction to control

activities on land that can adversely affect fish habitat. Consequently, fish habitat can be significantly compromised if the Provincial and Municipal jurisdictions responsible for land-based activities fail to consider the potential impacts of their decisions on fish habitat. Such land-based activities include, for example, the development and regulation of road and rail transportation corridors, urban and industrial development, hydroelectric projects, water diversion and extraction, farming, forestry and mining activities, waste management, and aquaculture operations.

Over the longer term, fish habitat will be maintained only if stewardship is endorsed by all elements of society. If Canadians want wild salmon to be conserved, they must restrict or control resource development in a manner that ensures fish habitat is protected for future generations. Currently, salmon habitat continues to be alienated despite the federal legislation that protects it. If fish habitat continues to be eroded, conservation of wild salmon will require extreme measures such as closure of fisheries, increased expenditures on enhancement (at the expense of biodiversity), and habitat restoration. Ironically, development that appears to be economically beneficial in the short-term may turn out to be economically unwise or ecologically disastrous in the long-term.

Fisheries and Oceans Canada has the legislative mandate through the Fisheries Act to manage fisheries for Pacific salmon to achieve conservation objectives. First Nations, recreational and commercial fisheries fall within this jurisdiction.

Pacific salmon are also caught in fisheries that occur beyond Canada's national boundaries. Canada, through participation in international commissions, was able to reduce and then eliminate all high seas interception of Pacific salmon originating in Canada. The four-nation North Pacific Anadromous Fish Commission now ensures that Canadian salmon are protected from foreign driftnets.

The Canada-U.S. Pacific Salmon Treaty was signed in 1985 to prevent overfishing in interception fisheries and to increase salmon production. Since then, many salmon populations have declined in abundance because of poor ocean survival associated with unusual environmental conditions,

overfishing and habitat degradation. The 1999 renewal of the Pacific Salmon Treaty with the United States provides greater assurance that conservation requirements will be met and distributes both the burden and benefits of conservation more equitably between the countries. The abundance-based framework of the 1999 Agreement places priority on the health of the stocks, rather than on entitlements to the fishing fleets of either nation. In principle, fisheries will be conducted at levels that can be sustained by the resource given current environmental conditions.

GLOBAL CONSERVATION ETHIC

The United Nations (UN) *Convention on the Law of the Sea* was adopted in 1982 to provide an international framework for the development and use of global marine resources. Recognition that over-exploitation threatens many of the world's fisheries has stimulated a new global conservation ethic. In 1992, the UN *Convention on Biological Diversity* was signed by the Government of Canada and other nations to promote the conservation and sustainable use of biological resources. It requires governments to integrate the principles of the Convention into national policies and legislation. In particular, it requires governments to promote the protection of ecosystems, natural habitats, and the maintenance of viable populations of species in natural surroundings. The Government of Canada is enacting legislation that reflects these new international agreements.

Canada played a key role in the development of the *Code of Conduct for Responsible Fisheries* proposed by the Food and Agriculture Organization (FAO) of the UN in 1995. The Canadian fishing industry is also committed to achieving sustainable marine and freshwater fisheries and has developed its own *Code of Conduct for Responsible Fishing Operations* as an essential step towards this objective. These non-binding agreements encourage responsible fishing practices and will contribute to the conservation of fish stocks and their aquatic environments.

The *precautionary approach* to fisheries management is one aspect of implementing these conventions and agreements. The UN advises that

"management according to the precautionary approach exercises prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in fisheries systems are slow to reverse, poorly understood, difficult to control, and subject to shifts in the environment and in human values." The federal *Oceans Act* passed in 1997 entails a commitment to manage marine ecosystems based on the precautionary approach with a view to conserving biological diversity and habitat productivity. The *UN Fish Agreement* ratified in 1999 also commits Canada to apply the precautionary approach to conservation and fisheries management.

FACTORS AFFECTING THE CONSERVATION OF WILD SALMON

The productivity and long-term viability of wild Pacific salmon in Canada are affected by many factors. Some factors like climate and marine environmental conditions are beyond the direct control of humans. Other factors affecting habitat are within human control, but require a shared vision and international or inter-departmental commitments to do so.

ENVIRONMENTAL UNCERTAINTY

Until recently, climatic or environmental effects on salmon survival were generally assumed to vary randomly from year to year, without trends or sudden shifts. It is now recognized that ocean climatic conditions can change in a persistent pattern. For example, the climate of the Northeast Pacific Ocean has changed dramatically since the late 1970s, as indicated by almost every historical climate and oceanographic record in the region. Coincident with this major change in climate, there was a change in the overall abundance of salmon in the North Pacific. More recently, south coastal British Columbia has experienced unprecedented high marine temperatures, unusual El Nino events, and extreme fluctuations in freshwater flow. During the same period, many salmon populations in the affected region experienced an unusually persistent period of poor marine survival. Increasingly, fisheries management plans must take these changing climatic

conditions into account, or recognize them as an additional source of uncertainty.

Habitat

Wild salmon depend on natural fish habitat. Fisheries and Oceans Canada has a long-term policy objective, outlined in the *Policy for the Management of Fish Habitat*, to achieve an overall net gain in the productive capacity of fish habitats. The implementation of the Policy involves the review of development proposals to identify potential threats to fish habitat and the incorporation of measures to avoid, mitigate, or compensate for these impacts. The guiding principle of No Net Loss is a fundamental component of the habitat policy to ensure that fish habitat is conserved. Under this principle, Fisheries and Oceans strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries resources due to habitat loss or damage may be prevented.

In spite of the Policy, the continuing loss and degradation of freshwater habitat is still considered a factor in the declining abundance of Pacific salmon. Protection of riparian areas and coldwater sources within watersheds may be essential to conserve salmon populations adversely affected by warming climatic trends. Urban growth, particularly on eastern Vancouver Island and in the Lower Mainland has caused losses of salmon production in small streams. Urban and industrial development within the watershed also degrades water quality through pollution from chemical spills, fertilizer and pesticide runoff, and aerial deposition. These effects sometimes extend to estuaries and coastal marine habitats that are important rearing areas for salmon.

Inherent in the commitment to preserve wild salmon is a commitment to protect natural fish habitat. However, protection of salmon habitat will require regulation of urban and industrial development within salmon-producing watersheds. All levels of government must be involved with stakeholders to share this responsibility. A positive step in this direction is the implementation of the *Habitat Protection Protocol* under the *Canada-BC Agreement on the Management of Pacific Salmon Fishery Issues.*

Until recently, the ocean habitat was thought to have ample capacity for both wild and cultivated salmon given historical records of Pacific salmon abundance. However, new research suggests that changes in ocean climate have reduced the ocean's productivity and capacity to support salmon. As habitat carrying capacity is reached, salmon growth and survival is reduced because the available food must be shared among greater numbers.

Fisheries

Pacific salmon are typically caught in fisheries as they mature and return to spawn. Simple models of population dynamics indicate that the *maximum sustainable yield* (MSY) will result from an intermediate level of spawning abundance at which enough eggs are laid to provide good recruitment to the next generation without reducing growth and survival by overcrowding the available habitat. However, determining the spawning abundance that will provide MSY in the future is inherently difficult. Reliable historical data are not always available, and productivity may have declined over time because of habitat loss or climate change. Consequently, values of MSY estimated from historical data may not be applicable to current fisheries.

Further, most salmon fisheries catch mixtures of different species and populations. Some species and populations are more productive than others, in part, as a result of natural variation in the quality and quantity of their freshwater habitat. The optimum harvest rate for productive populations will be excessive for less productive, co-migrating populations that are vulnerable to the same fishery. Unless it is possible to selectively harvest productive populations, the overall harvest rate must be reduced to ensure the conservation of less productive populations. Fisheries are being modified to harvest salmon more selectively than in the past. However, it is not always practicable to selectively harvest productive populations when they are mixed with less productive populations, especially for mixed populations of the same species.

Fisheries can also affect the role of salmon in freshwater ecosystems. Pacific salmon gain over 99% of their weight at sea and die in fresh water after spawning. Consequently, they are an important source of nutrients for nutrient-poor terrestrial and freshwater ecosystems. The ecosystem linkages

among salmon and other species are extensive and have not always been fully recognized.

SALMON CULTIVATION

Humans have been artificially rearing Pacific salmon and trout for over a century and salmon cultivation has become an important component of fisheries management in the Pacific Region. *Salmon enhancement* involves the use of hatcheries, spawning channels, or lake fertilization to supplement natural reproduction in a salmon population. Fish are cultivated to reduce mortality during the early life stages, thereby increasing the number of progeny per parent. Hatchery-reared juveniles (fry or smolts) are released into rivers or the ocean where they grow and develop naturally. In contrast, *salmon aquaculture* (or salmon farming) involves the cultivation of an artificial population, that is, reared in captivity throughout life.

Carefully managed, salmon enhancement should be an effective way to provide opportunities for terminal or selective harvest or to restore badly depleted wild salmon populations. However, cultivation can have demographic, ecological, and genetic impacts on wild salmon populations[2], although the genetic and ecological interactions between wild and cultivated salmon are not well understood. For example, by increasing the productivity of a supplemented population, enhancement may exacerbate problems for managing less productive wild populations caught in mixed-stock fisheries. When abundant, cultivated salmon may compete with wild salmon for food, territory or mates, or transfer disease.

Salmon enhancement also influences the evolutionary process and may erode genetic diversity or genetic adaptation of salmon to their natural habitat through hybridization, artificial selection, or inbreeding. Most negative effects of hybridization and inbreeding can be avoided by careful choice of broodstock and mating schemes during artificial propagation, but it is impossible to avoid some degree of artificial selection during cultivation. Genetic diversity will be most affected by artificial selection when cultivation

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[2] *Upstream: Salmon and Society in the Pacific Northwest*, 1996, U.S. National Research Council Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Academy Press, Washington D.C.

continues for many generations, affects many life stages, and greatly reduces mortality from levels sustained in nature.

The salmon aquaculture industry cultivates both Atlantic salmon and Pacific salmon (mostly chinook) in net pens in BC and Washington State. Farmed salmon do escape accidentally and are frequently caught in Pacific salmon fisheries, but usually in small numbers. Escaping exotic species like Atlantic salmon cannot interbreed with wild Pacific salmon and consequently do not pose a genetic risk. However, they can pose an ecological risk, as described above, if they occur in sufficient numbers, or become established as naturalized populations. Two instances of natural reproduction of Atlantic salmon in BC coastal streams have been confirmed to date.

Less is known about the number and distribution of farmed chinook and coho salmon that escape because they are difficult to distinguish visually from wild Pacific salmon. These fish pose the same kind of ecological concerns for wild salmon as those released from supplementation hatcheries, although probably to different degrees. Farmed fish are genetically different from wild fish because they are typically derived from different populations, and because farmers intentionally select for characteristics that are desirable in domestic culture but not in the wild. Consequently, Pacific salmon that escape from farms would pose a genetic risk if significant numbers were to interbreed with wild salmon. This risk is likely small if they interbreed only rarely.

Natural Variability and Knowledge Gaps

Fisheries and Oceans Canada manages fisheries to achieve spawning escapement targets or prescribed harvest rates in the face of tremendous uncertainty in pre-season forecasts of abundance and run timing. This uncertainty can be recognized and accommodated when the conservation objectives are fairly simple and focused on maintaining production from large salmon producing rivers. Increasingly, however, management efforts will be judged by their success in conserving both production and biological diversity.

Trends in freshwater and marine productivity depend on environmental conditions that cannot be forecast precisely. Recent years have been characterized by record high ocean temperatures and sea levels, as well as extreme ranges in water temperature and flow in the Fraser River. These extreme events have sometimes reduced the number of salmon able to reach their spawning grounds.

Ultimately, the effectiveness of the WSP will depend on how accurately today's knowledge reflects reality and anticipates the future. The principles described in this document represent current understanding or best judgement, but they still may be inadequate to provide long-term protection. Different approaches may be needed as more is learned about how climate, habitat, fishing and salmon cultivation interact to affect the productivity of wild salmon.

BIODIVERSITY AND WHAT TO CONSERVE?

The remarkable ability of salmon to return to their natal stream is called homing. Precise homing creates local populations, affording an opportunity for genetic adaptation whereby inherited traits improve survival (productivity) in the local environment. These local adaptations may be very important and explain why it is so difficult to establish new populations by transplanting eggs or juveniles from one location to another. The evolution of local genetic adaptations gives the conservation of Pacific salmon its uniquely complex character.

On the other hand, homing is not perfect and small numbers of salmon are known to stray to locations other than their natal streams. The spatial scale of local adaptation depends on the amount of straying among spawning sites and the degree to which different adaptations are favoured at each site. Much of today's research in conservation biology is concerned with where to draw the line that separates one local population from another. Where and how the line is drawn may influence the strategy and priority of conservation efforts. A recent publication summarizes the current views:

There is no "correct" answer to the question of precisely how much biological diversity and population structure should be maintained or can be lost to provide a long-term future for salmon. Scientific estimates–including uncertainties associated with them, are only part of the argument. Society must decide what degree of biological security would be desirable and affordable if it could be achieved, i.e., the desired probability of survival or extinction of natural populations, over what time and what area, and at what cost. Nonetheless, biological diversity and the structure of salmon populations are being lost at a substantial rate, and this loss threatens the sustainability of naturally reproducing salmon populations in the Pacific Northwest.[3]

PRINCIPLES FOR WILD SALMON CONSERVATION

The primary goal of the WSP, consistent with the UN *Convention on Biological Diversity*, is to ensure the long-term viability of Pacific salmon populations in natural surroundings and the maintenance of fish habitat for all life stages for the sustainable benefit of the people of Canada. Accordingly, the WSP applies to all wild Pacific salmon including those mixed with cultivated (enhanced) populations that are able to reproduce in natural surroundings. The following six principles will guide decisions and activities that affect the conservation of wild Pacific salmon.

WILD SALMON PRINCIPLE ONE: *WILD PACIFIC SALMON WILL BE CONSERVED BY MAINTAINING DIVERSITY OF LOCAL POPULATIONS AND THEIR HABITATS.*

The preservation of the quality and diversity of salmon habitat, and its accessibility to salmon, should be the primary consideration of any strategy to conserve wild Pacific salmon. Local salmon populations have evolved in different habitats and are largely isolated from other such populations. Because natural selection favours individuals that are best adapted to their habitat, local populations typically exhibit genetic adaptations. These genetic

[3] *Upstream: Salmon and Society in the Pacific Northwest*, 1996, U.S. National Research Council Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Academy Press, Washington D.C.

adaptations enhance the productivity of naturally-spawning populations of Pacific salmon. Consequently, the *potential* for sustained benefits from wild salmon is maximized by maintaining the greatest genetic diversity of salmon populations in the greatest number of habitats. In short, wild salmon production will be maximized when all natural habitat is fully utilized. The diversity of habitats that maintain genetic diversity is important to the future survival and evolution of Pacific salmon. Implementation of Principle 1 will be guided by the *Policy for the Management of Fish Habitat.*

WILD SALMON PRINCIPLE TWO: *WILD PACIFIC SALMON WILL BE MANAGED AND CONSERVED AS AGGREGATES OF LOCAL POPULATIONS CALLED* CONSERVATION UNITS.

The goal of maximizing sustainable benefits from local populations must be balanced against the cost and practicality of doing so. Thousands of local populations exist in British Columbia alone and it is logistically impossible to manage each population individually. Furthermore, many salmon fisheries harvest mixtures of populations and species and there are limits to how selectively populations can be harvested. However, it should be possible to conserve the genetic diversity of local populations, as required under Principle 1, by managing ***conservation units*** defined as aggregates of closely related populations with similar productivity and vulnerability to fisheries.

Conservation units will be delineated to ensure that evolutionarily distinct lineages are protected within geographic areas. Further partitioning into smaller conservation units may be required if differences in habitat lead to significant differences in productivity or life history among populations that preclude their management as an aggregate. Conservation units may therefore comprise a single local population (Harrison River white chinook), or an aggregate of many neighbouring local populations (West Coast Vancouver Island coho), or populations exhibiting a particular life history (river-rearing versus lake-rearing sockeye). Initially, identification of conservation units will be based on available information on genetic stock structure and the desired level of diversity to be maintained. Between 10 and 20 conservation units are anticipated for chinook and coho, with fewer than 10 conservation units for pink and chum, and more than 20 conservation

units for sockeye. The criteria for delineating conservation units within each species will be reviewed and updated through scientific research.

The WSP places priority on maintaining genetic diversity within conservation units, not on preserving individual populations. Small individual populations are always at risk of extirpation because of random events. Straying from genetically similar populations within the conservation unit is essential to replace genetic diversity lost through random genetic drift, or to repopulate habitat following extirpation from random demographic events. Thus, conservation of an aggregate of populations connected by straying is necessary to maintain genetic diversity and production in the longer term."

WILD SALMON PRINCIPLE THREE: *MINIMUM AND TARGET LEVELS OF ABUNDANCE WILL BE DETERMINED FOR EACH CONSERVATION UNIT.*

The precautionary approach to fisheries management requires that operational targets and constraints be expressed in measurable terms. Accordingly, a ***limit reference point*** (LRP) and one or more ***target reference points*** (TRP) will be specified for each conservation unit based on estimates of productive capacity. These reference points will be used in developing management plans that provide opportunities to optimize sustainable benefits to Canadians.

The Technical Appendix provides an example of how LRPs and TRPs could be defined. The LRP will be expressed as a minimum spawning escapement or similar measure of abundance required to ensure the long-term viability of the conservation unit. Abundance below the LRP would significantly increase the risk of extirpation of local populations within the conservation unit, thereby reducing future production and genetic diversity within the species. A TRP might be defined as the spawning escapement that provides MSY from the conservation unit under equilibrium (i.e., average) conditions, or a higher spawning escapement that achieves a broader ecosystem objective.

These reference points define three stock abundance zones. A total abundance above the TRP is in the "target zone". A total abundance below the TRP but above the LRP implies that the conservation unit is secure but requires "rebuilding" to optimize sustainable production for future generations. A total abundance below the LRP implies a stock "collapse" and indicates that the long-term viability of the conservation unit is at risk.

WILD SALMON PRINCIPLE FOUR: ***FISHERIES WILL BE MANAGED TO CONSERVE WILD SALMON AND OPTIMIZE SUSTAINABLE BENEFITS.***

Following the precautionary approach, management plans should be specified for each conservation unit through pre-season consultation. These plans should include options or "harvest rules" based on a range of abundance forecasts or in-season estimates for the conservation unit. The pre-defined nature of these harvest rules ensures that in-season management actions can be taken without delay. Typically, harvest rules will be chosen to optimize long-term sustainable benefits or productive capacity within the conservation units. Objectives and corresponding harvest rules may differ among conservation units, and will be developed in consultation with First Nations and stakeholders, and in accordance with other Departmental policies such as *An Allocation Policy for Pacific Salmon* released in October 1999.

Conservation units and LRPs will be defined according to biological principles applied equally to all conservation units regardless of their economic or social value. In contrast, TRPs will be defined to optimize sustainable benefits and will explicitly consider human social and economic values. To be acceptable, a harvest rule for Pacific salmon must ensure that the probability of failing to achieve the LRP for a conservation unit is very low. If abundance in a conservation unit falls below the LRP, then a pre-defined rule should prescribe actions that will be taken to restore escapements and preserve the unit. If abundance is above the LRP but below the TRP, removals should be restricted to allow abundance to remain above the LRP and to rebuild to above the TRP. Management plans for some conservation units may allow slower rates of rebuilding than for others in order to provide fishing opportunities on very productive conservation units.

Scientific advice will be required to conduct the risk analyses that clarify the likely consequences and tradeoffs associated with alternative harvest rules. The development of management plans should consider: (1) biological limitations to salmon production in both the freshwater and marine habitats; (2) the ecological role of Pacific salmon within the affected ecosystem; (3) short-term versus long-term harvest objectives and economic/cultural values and (4) uncertainty and the precautionary approach.

WILD SALMON PRINCIPLE FIVE: ***SALMON CULTIVATION TECHNIQUES MAY BE USED IN STRATEGIC INTERVENTION TO PRESERVE POPULATIONS AT GREATEST RISK OF EXTIRPATION.***

Genetic diversity and fitness are threatened by chance events whenever local population abundance declines to critically low levels. Under these circumstances, short-term intervention to increase abundance will be beneficial if the genetic changes that result from the intervention are less detrimental than the genetic changes that occur from continued low abundance. Technologies such as fish culture, broodstock rearing (aquaculture), and gene banking may be used strategically to reduce loss of genetic diversity at critically low abundance. The same technologies can also be effective in re-introducing salmon species to habitat where they formerly occurred. However, strict guidelines are required to ensure that these technologies do not adversely and irreversibly affect the long-term productivity of the conservation unit.

Salmon cultivation has been used as a tool for stock rebuilding, and for the provision of other associated social and economic benefits. Since 1977, it has been delivered primarily through the federal Salmonid Enhancement Program (SEP). However, new and developing policies are shifting the focus away from a production-oriented program to one that focuses on rebuilding wild stocks through appropriately scaled, short-term supplementation, habitat restoration, and community stewardship. To better define the objectives of the new program, stakeholders will be consulted on future directions and opportunities. A *Salmon Enhancement Policy* is being

developed to ensure operational consistency with other policies within the New Direction framework.

WILD SALMON PRINCIPLE SIX: ***FOR SPECIFIED CONSERVATION UNITS, WHEN GENETIC DIVERSITY AND LONG TERM VIABILITY MAY BE AFFECTED, CONSERVATION OF WILD SALMON POPULATIONS WILL TAKE PRECEDENCE OVER OTHER PRODUCTION OBJECTIVES INVOLVING CULTIVATED SALMON.***

Inevitably, some forms of salmon cultivation will lead to ecological or genetic interactions between wild and cultivated salmon. These interactions may affect the genetic diversity and long-term viability of wild salmon. The conservation of wild Pacific salmon clearly requires a conscientious effort either to understand and avoid potential deleterious long-term consequences of interactions, or to limit such interactions to specific geographic zones. Accordingly, all proposals involving salmon cultivation must be reviewed carefully to minimize adverse effects on natural production.

CONSULTATION

Over the next six months, Fisheries and Oceans Canada will discuss the implementation of the WSP in consultations with a broad range of interested parties. Bilateral consultations will be undertaken with First Nations, in order to meet the fiduciary responsibilities of the Crown. There will also be consultations and discussions with the Province of British Columbia and the Pacific Fisheries Resource Conservation Council.

Fisheries and Oceans Canada staff will convene facilitated meetings with representatives of First Nations, recreational and commercial fishing sector representatives, the aquaculture industry, environmental and stewardship groups, and other interested parties in the spring of 2000. Consultations will be co-ordinated with other planned consultations on the future of the Salmon Enhancement Program. Issues for discussion will include but not be limited to:

- clarity of the policy,
- general orientation of the policy,
- the role of the policy on future directions for the Salmon Enhancement Program,
- processes for establishing target reference points (TRPs) and limit reference points (LRPs),
- alternative harvest policies using LRPs and TRPs,
- strategic use of enhancement in addressing wild stock problems.

The general public is invited to comment on the Wild Salmon Policy. Copies of this document are available on the internet at http://www-comm.pac.dfo-mpo.gc.ca/wsp-sep-consult and at Fisheries and Oceans Canada offices throughout BC and the Yukon. Comments from all interested parties are welcome and can be provided through e-mail to wsp.sep.consult@pac.dfo-mpo.gc.ca
or in writing to:
Dr. Laura Richards
Fisheries and Oceans Canada
460 - 555 West Hastings Street
Vancouver, BC
V6B 5G3

Following this consultation period, a final policy statement is anticipated for release later in 2000.

GLOSSARY

Anadromous[1] The life history characteristic of returning from the sea to reproduce in fresh water.

Artificial selection Selection by humans; domestication; selective breeding (see also *Selection*).

Aquatic[2] Living in or near water.

Biological diversity means the variability among living organisms from all sources - including terrestrial, marine, and other aquatic ecosystems - and the ecological complexes of which they are a part. This includes diversity within species, between species and of ecosystems.

Benefit considers the role of wild salmon in ecosystems as well as to humans through consumptive and non-consumptive uses.

Captive broodstock[1] (in salmon) is a form of cultivation where salmon are held in captivity for most or all of their life cycle for the purpose of producing juveniles.

Conservation unit is 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.

A *cultivated* species or population is one that is artificially propagated completely or in part by continuing human intervention to increase production or meet other human needs.

Domestication[2] The adaptation of plants and animals for life in intimate association with man.

Ecosystem[2] A community of organisms and their physical environment interacting as an ecological unit.

Extirpation is the extermination of a population of a species from a given area.

Fish habitat[3] means natural spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes.

Fitness[2] The relative competitive ability of a given genotype conferred by morphological, physiological or behavioural characters, expressed and usually quantified as the average number of surviving progeny of one genotype compared with the average number of surviving progeny of competing genotypes.

Gene banking is the cryopreservation (freezing at extremely low temperatures) of salmon sperm to be used in artificial reproduction at some later date.

Genotype[2] is the hereditary or genetic constitution of an individual.

Hybridisation[2] is any crossing of individuals of different genetic composition resulting in hybrid offspring.

Inbreeding[2] Mating or crossing of individuals more closely related than average pairs in the population.

Intervention[1] means the application of technology to the objective of artificially increasing salmon survival and abundance.

Local populations[4] are groups of one or more subpopulations that are relatively isolated from other such groups and are likely adapted to the local habitat. Throughout this paper, the use of the word population, unless qualified, is equivalent to a local population.

Marine[2] Pertaining to the sea.

Migration[2] means the movement of an organism of group from one habitat or location to another.

Ocean ranching[1] is the artificial propagation of a fish stock by a private group with the expectation of some limited privilege to access increased production to cover operating and harvest costs.

Optimum[1] means the best that can be achieved under the influence of conflicting factors.

Precautionary approach[5] is a concept that was enshrined in Principle 15 of the Rio Declaration of the UN Conference on Environment and Development which states: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Reference point[5] is an estimated value derived from an agreed scientific procedure and/or and agreed model which corresponds to a state of the resource and/or of the fishery and can be used as a guide for fisheries management. Some reference points are general and applicable to many fish stocks, while others should be stock-specific. A distinction should be made between *target* reference points and *limit* reference points, or thresholds, the latter representing low states of the stock to be avoided.

Selection[2] Non-random differential reproductive success of different genotypes in a population.

Spawning[2] The release of gametes or eggs into the water.

Species[2] A taxon of the rank of species; in the hierarchy of biological classification the category below genus; the basic unit of biological classification; the lowest principal category of zoological classification.

A *subpopulation*[4] is a group of interbreeding organisms that is partially isolated and genetically differentiated from other such groups, and that may be adapted to the local habitat.

Stock[6] is the part of a fish population which is under consideration from the point of view of actual or potential utilization.

Sustainable use means the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations. Sustainable is not meant to imply that abundance is constant.

Terrestrial[2] Pertaining to, of living habitually on, the land or ground surface.

A *wild salmon*[1] is a salmon produced by natural spawning in fish habitat from parents that were spawned and reared in fish habitat. This definition recognizes that wild salmon may continue to exist even after intensive cultivation of a previously wild population. Wild salmon in cultivated populations warrant protection under the WSP to ensure the long-term viability of populations in natural surroundings. However, the WSP may not afford similar protection to transplanted salmon that now spawn in habitat where the species did not occur naturally.

A *wild salmon population*[1] is a local population comprising naturally spawning and rearing wild salmon.

Sources of Definitions

1. Defined by Fisheries & Oceans staff for the WSP.
2. A Dictionary of Ecology, Evolution & Systematics, 2nd edition, Lincoln, Boxshall, Clark., 1998.
3. Fisheries Act, Section 34.
4. Defining Conservation Units for Pacific salmon using Genetic Survey Data. Wood & Holtby, 1998, p. 233-250 *In* Action before Extinction, World Fisheries Trust.
5. FAO Technical Guidelines for Responsible Fisheries. Vol. 4. Fisheries Management. 1997. United Nations.
6. Computation and Interpretation of Biological Statistics of Fish Populations. W.E. Ricker. 1975. Fisheries Research Board of Canada, Bull. 191.

TECHNICAL APPENDIX

The following example illustrates how principles 3 and 4 of the WSP could be applied.

Estimating productive capacity:
Salmon stock assessment involves modelling stock productivity, typically by relating the number of spawners (S for stock) to the number of progeny expected, on average, to return as adults next generation (R for recruitment). The stock-recruitment curve shown in the upper frame of Figure 1 is typical of productive sockeye salmon populations in the Fraser River. To facilitate comparison with other examples, abundance has been scaled as a proportion of the maximum total return at equilibrium.

Low harvest rates allow large escapements that sustain large total returns; higher harvest rates lead to smaller escapements that sustain smaller total returns. In this example, sustained harvest rates (h_E) above 80% cause extirpation. At equilibrium, a harvest rate of 63% provides maximum sustainable yield (MSY) from a total return of R*, resulting in a spawning escapement of S*. Note that S* is the number of spawners expected to produce R* and MSY next generation, thereby maintaining equilibrium. Other harvest rates are also sustainable (if less than 80%), but provide lower sustainable yield at equilibrium.

Defining the LRP:
In reality, no stock is ever in equilibrium, and there is always some risk of extirpation due to chance events even for otherwise healthy, abundant stocks. The probability of extirpation, shown as a dashed line labelled "prob." in the lower frame of Figure 1, increases almost exponentially as stock abundance decreases. Although there is no threshold abundance above which the stock is secure, the LRP is intended to provide a consistent benchmark of risk across conservation units. A total abundance below the LRP implies a stock "collapse" and indicates that the long-term viability of the conservation unit is at unacceptable risk. In Figure 1, the LRP is arbitrarily fixed at 10% of the maximum equilibrium stock size merely to illustrate how reference points would be used.

Defining the target zone:
The number of spawners providing MSY at equilibrium (S*) is often used as a target reference point to delimit the lower end of a target zone. This is because spawning escapements below S* would not optimize any long-term objectives involving sustainable yield, fishing opportunity, or health of the ecosystem if the conservation unit were managed as a single stock in isolation of other conservation units. A spawning abundance below S* but above the LRP implies that the conservation unit is secure but requires "rebuilding" if it is to provide maximum sustainable production in future generations. It is important to recognize that overall economic or social benefits from mixed-stock fisheries may be optimized when spawning abundance in unproductive conservation units remains below the target zone. However, the LRP explicitly limits the extent to which production from individual conservation units can be compromised in attempting to maximize overall benefits.

Finding acceptable harvest rules:
A harvest rule specifies how harvest rate should vary with total abundance returning to a conservation unit. Several possible harvest rules are illustrated in Figure 2 for the productive stock example. Option A (solid line) is the default harvest rule recommended for implementation of the U.S. Magnuson-Stevens Fishery Conservation and Management Act[4]. Option B is the deterministic optimal fixed harvest policy, and option C is the deterministic optimal fixed escapement policy. The lower frame in Figure 2 indicates the escapement that would result from a particular run size if no harvest were taken (dashed line) or if harvest rule A were applied (solid line).

To be acceptable, a harvest rule must allow rebuilding when abundance is below the target zone. This means that the proposed harvest rate must be less than the equilibrium harvest rate that, on average, would maintain current abundance. In other words, the proposed harvest rule must lie below the line marked h_E in Figure 2 whenever abundance is below the target zone.

The harvest rule must also ensure that the probability of collapse to below the LRP is acceptably low. Given a pre-season forecast or in-season-

[4] Technical Guidance on the Use of the Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act, NOAA Technical Memorandum

determination of total returns for a conservation unit, shown as a probability distribution in the upper frame of Figure 3, it is possible to compute the chances of falling below the LRP for any particular harvest rule of interest (in this case, option A from Figure 2). This risk is equal to the filled area of the forecasted escapement distribution to the left of the LRP in the lower frame of Figure 3, when expressed as a proportion of the overall area under the forecast distribution.

Defining acceptable risk:
Determining whether the risk of falling below the LRP is acceptable would be the responsibility of the accountable manager in consultation with stakeholders. To provide guidance and to ensure a consistent approach, default levels of acceptability could be determined from theoretical considerations of incremental risk. The strength of this approach is that it provides managers with the flexibility to manage trade-offs based on the social and economic costs of incremental reductions in risk. In short, it allows managers to do their job with explicit and transparent documentation of the risks being accepted in fisheries management decisions.

Application where information is lacking:
The conceptual approach described in Figures 1-3 is logically sound for all scenarios, but reliable information about productivity will be unavailable for some conservation units. In such cases, reference points cannot be determined precisely, and it will be necessary to rely on expert judgement until more definitive information becomes available. In other cases, it may be impractical to measure abundance within a conservation unit, but it may be possible to control and measure harvest rates in association with marked "indicator stocks", as is currently done to manage most coho and chinook salmon stocks. Uncertainty will increase wherever the availability of data precludes reliable estimation of reference points or implementation of harvest rules. However, the precautionary approach to fisheries emphasizes that lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. This implies that harvest rules should be appropriately risk averse wherever our knowledge is uncertain.

Figure 1. Possible limit (LRP) and target reference points (S* and R*) with respect to a typical stock-recruitment curve for a very productive Pacific salmon population . The dashed line labelled "prob." indicates approximately how the probability of extirpation (within some unspecified time period) varies with abundance; the solid line labelled "h_E" shows the relationship between harvest rate and spawning escapement at equilibrium.

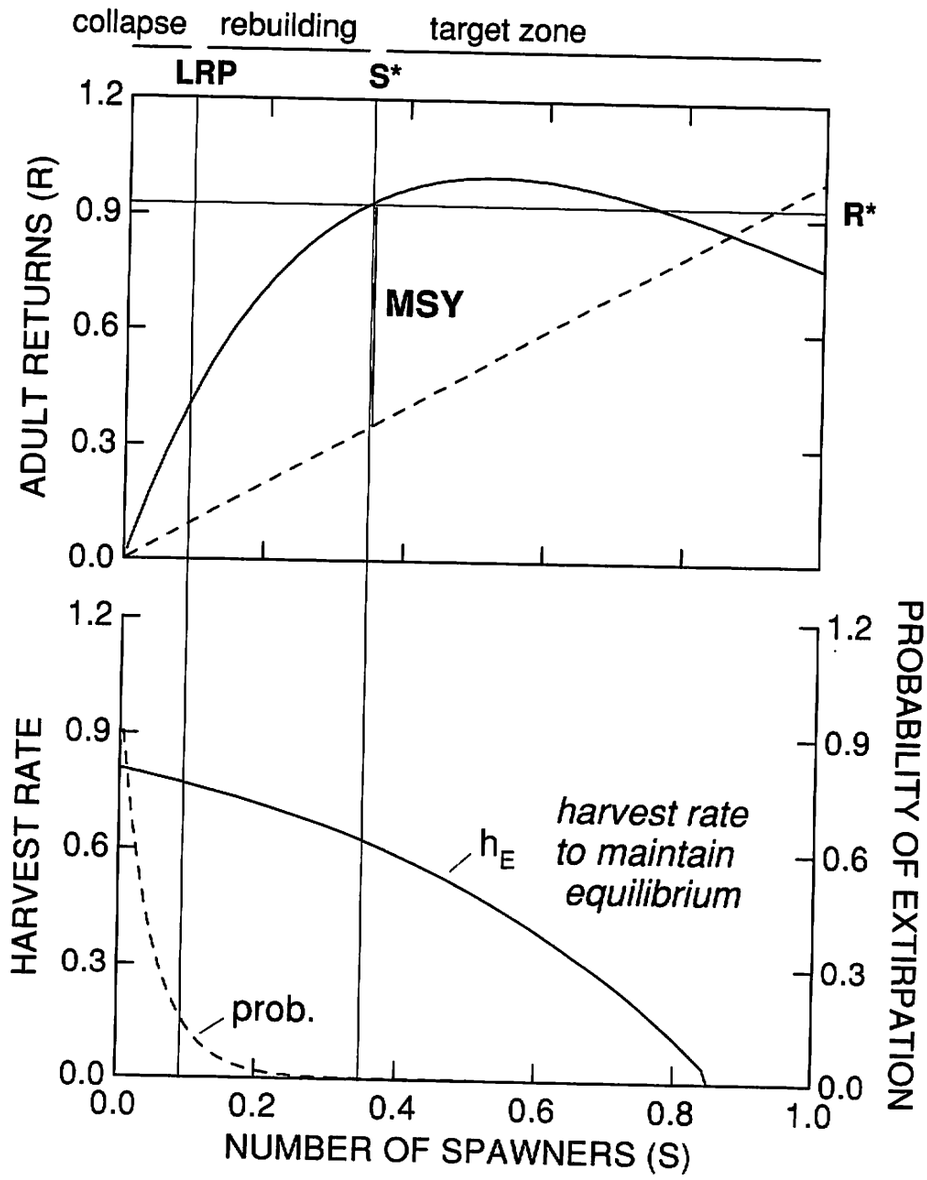

Figure 2. Schematic representation of reference points and harvest rule options for the very productive Pacific salmon population described in Figure 1. See Technical Appendix for explanation.

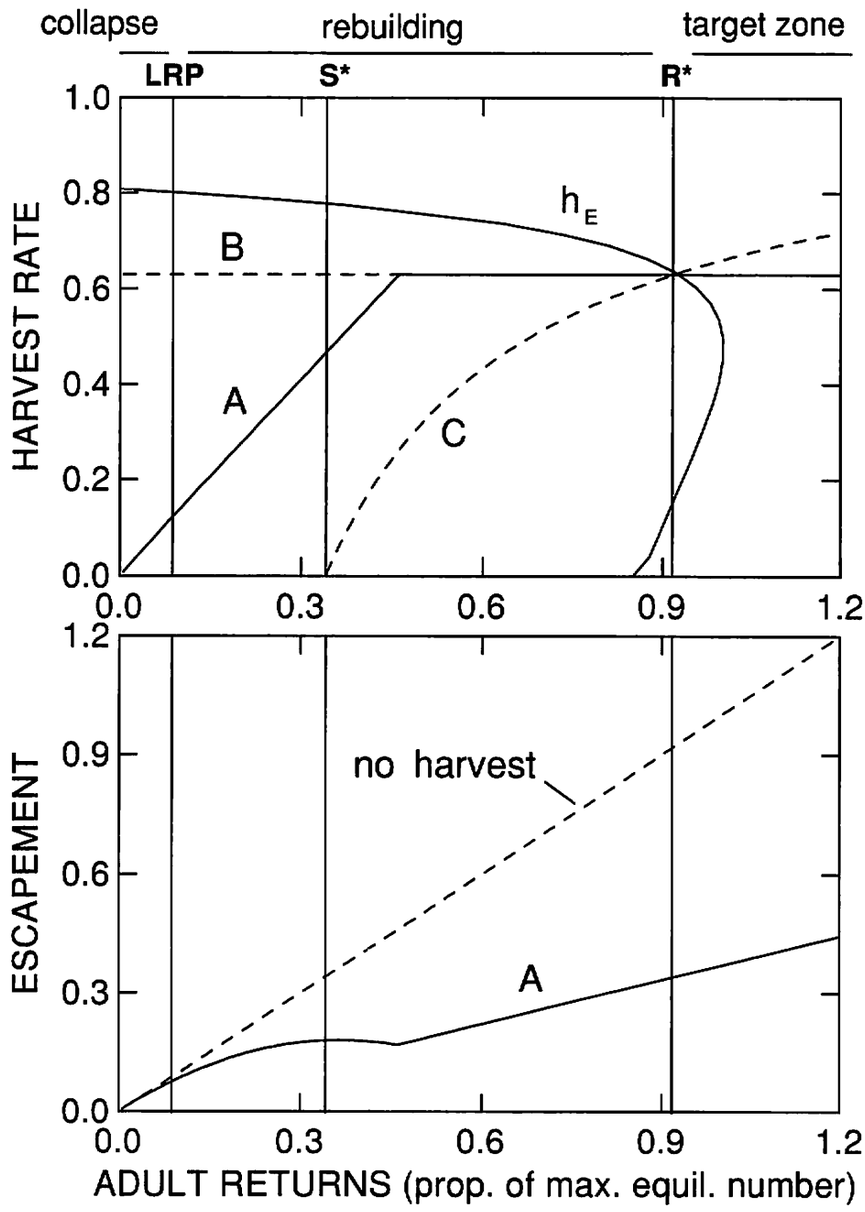
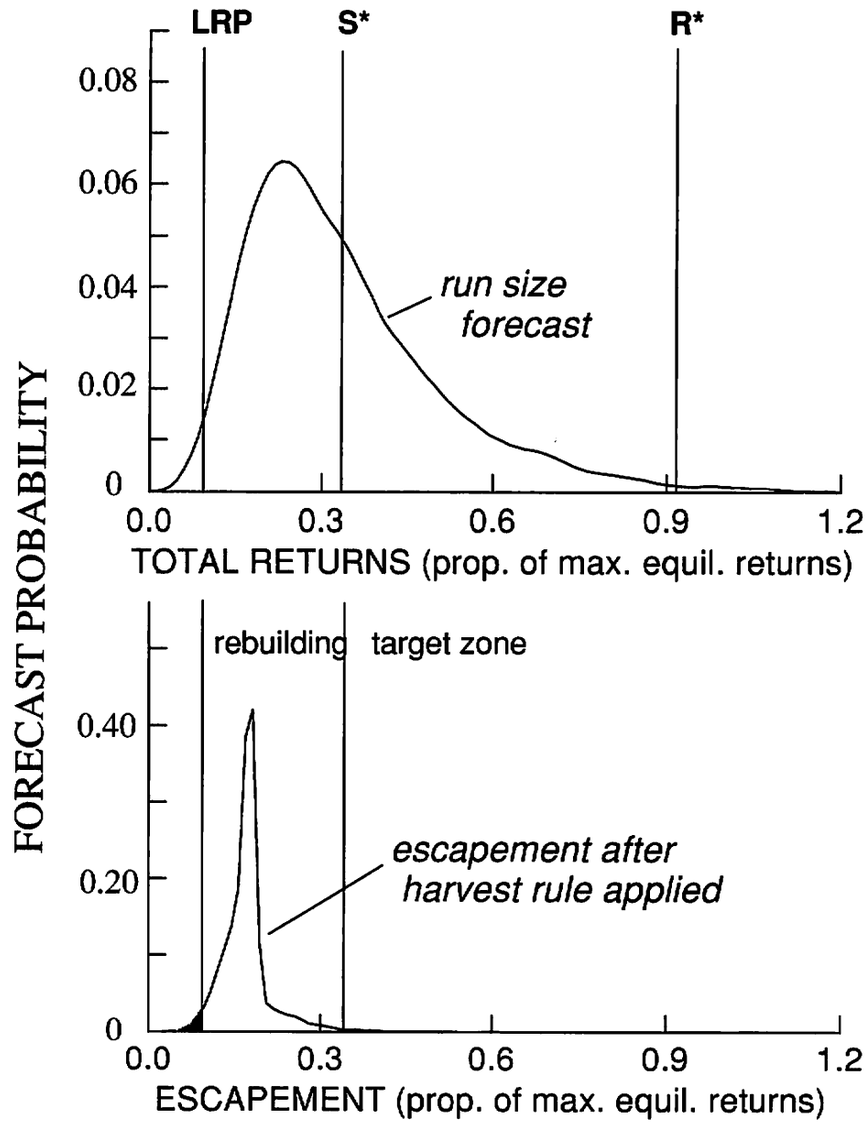
Figure 3. Determining whether a harvest rule will ensure an acceptable probability of achieving the LRP given a pre-season forecast or in-season determination of abundance. See Technical Appendix for explanation.