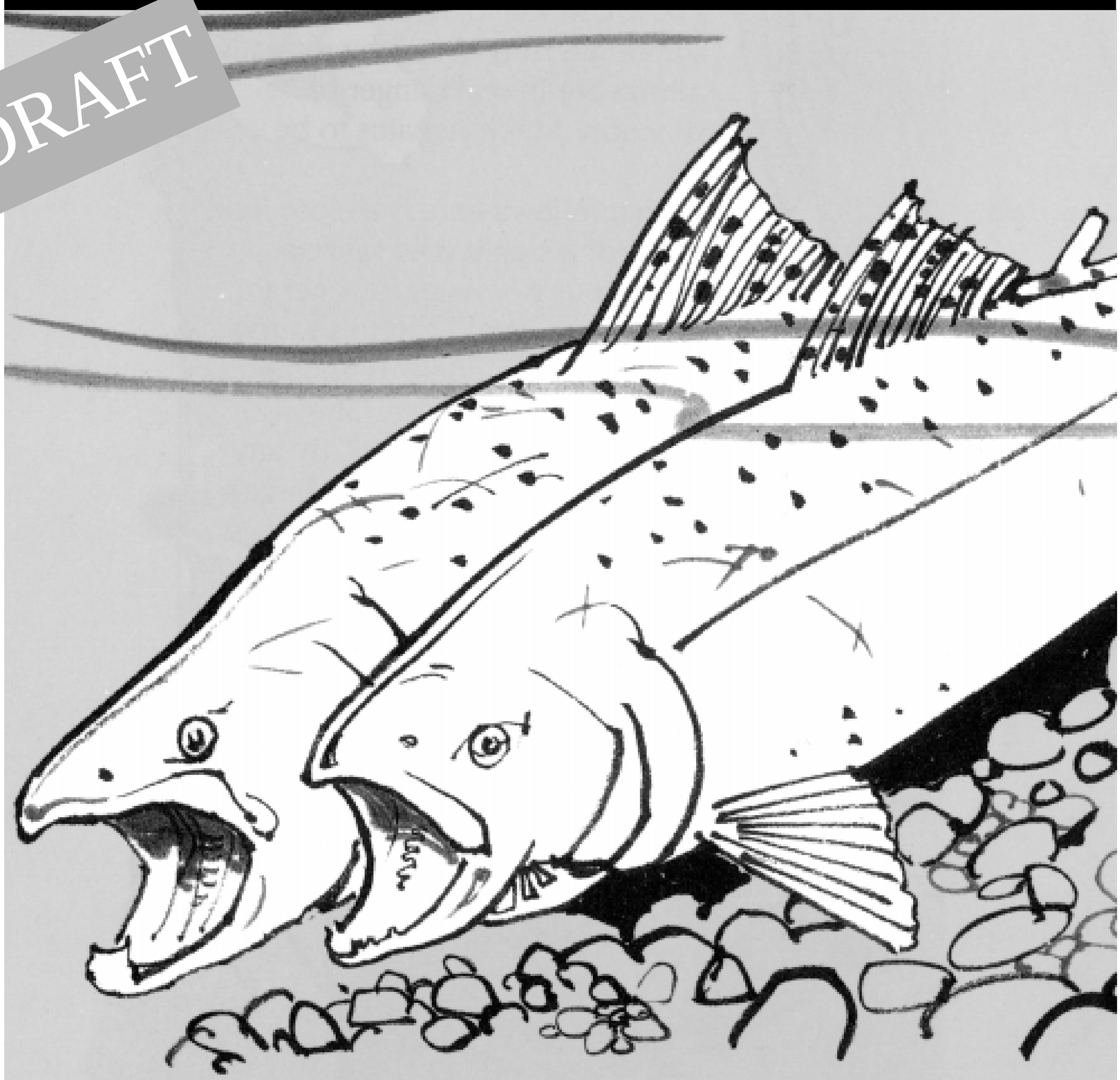
Conservation of Columbia Basin Fish

Building a Conceptual Recovery Plan

A Publication of the Federal Caucus • December 1999

DRAFT



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The Federal Caucus

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Note to Readers
Purpose of the Conservation of Columbia Basin Fish Paper

The Conservation of Columbia Basin Fish Paper outlines the difficult choices that face the Pacific Northwest if listed salmon, resident fish and aquatic species are to recover. The final paper, to be produced after a public comment period on this draft, will provide a conceptual anadromous fish recovery plan that provides context and linkages for other federal, regional efforts and actions within the four Hs (habitat, harvest, hatcheries and hydropower). It will also describe opportunities and relationships for restoration and recovery of listed resident fish and aquatic species.

The Federal Caucus developed this draft paper to stimulate a constructive dialogue among the governments and the people of the region about species recovery. We hope it demonstrates that major management decisions by the region are needed in each H.

The draft paper presents the following:

- Basic options under each of the Hs and a limited number of alternatives that mix the available options in a way that is useful for discussion purposes.
- This draft provides a preliminary quantitative analysis of the biological effects of some of the alternatives. These tools should be used with caution because the biological and feasibility analysis to determine if improvements will work has not been completed for all ESUs and has not been thoroughly peer reviewed. However, it does demonstrate that if we are going to prevent extinction and recover these species, major management decisions will be necessary in each H.

The draft paper does not present the following:

- A preferred option or alternative; this is not a decision document.
- An individual agency's position.
- A roadmap of actions to avoid jeopardy for any species.
- A full recovery plan including recovery goals and required management actions.
- Complete scientific analysis. Much work remains to be done on refinement of quantitative tools to assess extinction risk and recovery potential and the feasibility of achieving survival improvements through habitat, hatchery and hydropower actions.
- Address economic, legal or political feasibility of any option or alternative.

We present this draft document and hope that the issues we have identified will contribute to a constructive dialogue among the governments and the people of the region. The recovery of the Northwest icon, Pacific salmon, and listed resident fish and aquatic species depends on it.

Table of Contents

List of Tables

List of Figures

Conservation of Columbia Basin Fish

Building a Conceptual Recovery Plan

Executive Summary

Introduction

Native salmon and steelhead, and many **resident fish** species are in decline throughout the Columbia River Basin. Recent analyses indicate that **extinction risks** for Snake River salmon and steelhead **populations** are significant. These analyses confirm that major changes must be made in a wide range of activities that cause harm to those stocks if salmon **recovery** is to be successful. Analyses for the remaining salmon and steelhead populations in the basin will be completed in a few months. Making changes to recover these fish will require all of the governments and people of the Pacific Northwest to confront tough choices. The success of salmon recovery in the Columbia Basin depends upon the willingness of the region to make those tough choices.

Words in bold are defined in the Section 6, Glossary and Acronyms. Some are also defined in sidebars.

An **evolutionarily significant unit** is a population or group of populations that is considered distinct for purposes of conservation under the ESA.

A **threatened** species under the ESA is a genetic population that is at risk of becoming endangered in the foreseeable future.

An **endangered** species is any species of plant or animal in danger of extinction throughout all or a significant portion of its range.

Certain changes can result in immediate improvements, while others will require more time to show results. Some changes can be implemented using existing authorities and capabilities, others will require new authorizations and congressional support. Some of these changes are decisions of federal agencies, others depend largely on state or local commitments.

This paper presents options for habitat, harvest, hatcheries and hydropower, and shows how the options can be combined into integrated alternatives. Both the options and alternatives are simplified examples, intended to represent broad choices. The options are not intended to capture exact prescriptions of actions; the integrated alternatives do not represent the only combinations of options possible. None should be viewed as preferred, and there are practical or legal obstacles to implementing some of the options or integrated alternatives.

The purpose of this paper is to outline the fundamental choices that face the region if salmon recovery is to succeed. The objective is to stimulate an honest and constructive dialogue among the governments and the people of the region. That honest dialogue holds the best hope for a durable set of commitments by which to recover salmon stocks and the health of the rivers upon which they depend. This dialogue must take into consideration tribal resources and treaty rights.

Background

Historically, 10-16 million salmon and steelhead returned each year to **spawn**, but by the 1960s, that number had dropped to about 5 million. Today, only about a million fish return, and most of them originate from hatcheries, not from the wild. Due to this steep decline, the National Marine Fisheries Service (NMFS) has **listed** 12 Columbia River Basin salmon and steelhead **Evolutionarily Significant Units** (ESU) as **threatened** or **endangered** under the Endangered Species Act (ESA). The U.S. Fish and Wildlife Service (USFWS) has listed bull trout, Kootenai River White Sturgeon, and five other aquatic species (Snake River snails) as threatened or endangered.

The deterioration of the Columbia's once-numerous fish **runs** can be traced to the economic development of the basin. The human activities that have caused the decline of these fish – often referred to as the "Four Hs" – are habitat, harvest, hatcheries, and hydropower. Forestry, agriculture, mining, and urbanization have altered or destroyed tributary *habitat*. Fishing, or *harvest,* has reduced the number of adult fish that return to spawn. *Hatcheries* have introduced **inbreeding** and competition, may have been a source of disease for **wild fish**, and have in some cases induced **fisheries** to harvest at rates too high for natural stocks. And *hydropower* dams on the Columbia and Snake rivers have blocked and inundated **mainstem** habitat, altered natural flows for fish and aquatic species, impeded passage of migrating fish, and created a series of pools where fish predators reside.

The people of the Pacific Northwest have made efforts to turn around the salmon and steelhead decline. Fish managers in the basin have dramatically reduced harvest. They have also made substantial progress to address hatchery practices and established programs to improve habitat. Although there have been many improvements at dams and in hydropower operations, the major hydropower dams on the Snake and Columbia rivers continue to be a significant source of mortality for some stocks of migrating fish. Recently, regional debate has focused on the eight federal dams on the Snake and Columbia rivers, the role they have played in fish declines, and whether some of the dams should be removed. Given the impacts of extensive hydropower development on the salmon runs of the Columbia Basin, this focus is entirely understandable and appropriate. At the same time, however, maintaining a broad, more comprehensive focus on other major sources of declines is equally important if recovery efforts are to succeed.

Last year, nine federal agencies formed a *Federal Caucus* to examine opportunities the region has in each of the Hs for recovering listed salmon, steelhead, resident fish and other aquatic species. Our intent was to develop a conceptual recovery plan that could guide future federal actions. This paper examines several of the basic options for future management in each of the four Hs. These options are not intended to be exhaustive. Using these options, the Federal Caucus developed a set of integrated alternatives, or packages of options, which mix and match the various options. These integrated alternatives are intended to illustrate the type of integrated strategies that will be required for successful recovery. They are not presented, however, as the exclusive set of packages that are possible.

The goal of the paper is to stimulate discussion of what the region can do to recover salmon and steelhead and other aquatic species. The Federal Caucus hopes to encourage a constructive debate that is broadly focused and results in a regionally supported comprehensive strategy across the four Hs.

The paper emphasizes that salmon recovery is but one of several environmental challenges facing the governments of the Pacific Northwest. Addressing the extensive loss of water quality throughout the basin is a complementary objective. Columbia River streams, both mainstem and tributaries, have been designated as **water quality limited** under the Clean Water Act. The degraded condition of these streams is directly related to declining fish populations throughout the basin.

Goals and Objectives

The Federal Caucus suggests five goals for a regional fish recovery plan:

- Conserve Species. Avoid extinction and foster long-term survival and recovery of Columbia Basin salmon and steelhead and other aquatic species.
- Conserve Ecosystems. Conserve the **ecosystems** upon which salmon and steelhead depend.
- Assure Tribal Fishing Rights. Restore salmon and steelhead populations over time to a level that provides a sustainable harvest sufficient to allow for the exercise of meaningful **tribal fishing rights**.
- Balance the Needs of Other Species. Ensure that salmon and steelhead conservation measures are balanced with the needs of other native fish and wildlife species.
- Minimize Adverse Effects on Humans. Implement salmon and steelhead conservation measures in ways that minimize their adverse human effects.

The Options for Each H

The Federal Caucus considered a range of options for each H. There were three purposes in developing these options: to consider solutions or actions that had not yet been explored; to test the **sensitivity** of different

The following options are intended to represent broad choices in direction and strategy for each H. They do not represent exact prescriptions of actions and measures that would ultimately be implemented as part of an overall recovery plan. Specific actions and measures presented in this paper or in related documents are for illustration purposes only.

fish populations at various **life stages** to actions in the different Hs; and to stimulate regional dialogue on the tradeoffs and uncertainties involved in selecting a suite of actions to recover salmon and steelhead populations.

Anadromous fish migrate from fresh to saltwater when young, spend most of their adult life in the ocean, and then return to freshwater to spawn. **Salmonids** tend to return to their stream of origin.

Habitat Options

The quality and quantity of tributary freshwater and **estuary** habitat in much of the Columbia River Basin has declined dramatically in the last 100 years. Forestry, farming, grazing, road construction, hydropower development, mining, and urbanization have radically changed the historical habitat conditions of the Columbia River Basin. The lands and waters of the basin no longer support the array of **anadromous** fish, resident fish, wildlife, and plant communities that existed prior to European settlement. Habitat conditions on federal land are generally better than conditions on nonfederal land. In addition, federal programs are likely in the long term to improve habitat **capacity** on most federal land. Improvement of habitat conditions on nonfederal land is less certain. Without substantial improvements in land and water activities, habitat conditions across the basin will continue to erode and undercut progress in salmon recovery efforts in the other Hs. Improvements in habitat for salmon and steelhead have the additional benefit of improving conditions for all other aquatic species, wildlife, and native plant communities in the **watershed** as well.

The objectives of the habitat options under consideration by the Federal Caucus are to: prevent further degradation of tributary and estuary habitat conditions and water quality; protect existing high-quality habitats; and restore habitats on a priority basis. The primary difference among the habitat options is the level of state and local effort and participation, the level of federal support, and the level of federal regulation. The Federal Caucus does not anticipate that management on federal lands will vary under these options. Under all options, federal land management agencies will continue to pursue their current programs and consult on those programs under the ESA. All options call for substantially increased federal coordination, assessment and planning, and immediate federal actions.

Option 1: Coordinate and Prioritize Federal Actions

- Under this option there would be moderate increases in efforts to protect and restore habitat, a measurable increase in federal action and coordination, and increased habitat assessments and planning efforts using federal funds. Immediate actions would reduce imminent risks and immediately improve survival.

Option 2: Coordinated Regional Plans

- Under this option, state, tribal, local, and federal entities would significantly increase their level of coordination, planning and habitat implementation. There would also be an increase in federal funding for habitat assessments, plans, immediate actions, and monitoring. Initially, there would be an increased allocation of federal funds to assessments and planning that would precede all but immediate actions. Immediate actions would reduce imminent risks and immediately improve survival. One major mechanism for accomplishing this would be a substantial and explicit tie between water quality compliance efforts (already under court orders in three states) and salmon recovery.

Option 3: Increased Federal Role under Clean Water Act and ESA

- This option has similar components to Option 2, except it includes increased regulation by the federal agencies under the CWA and ESA. This option would be implemented if the region cannot develop a coordinated plan with state and local governments.

Harvest Options

Salmon fishing has been a central feature of Northwest tribal culture, religion, and commerce for generations. Tribal harvest may historically have been as high as 4 to 6 million fish. With the arrival of European settlers and the advent of canning technologies in the late 1800s, commercial fishing developed rapidly. Commercial salmon and steelhead harvest has been as high as 2.1 million fish in 1941 to as low as 68,000 fish in 1995.

To have a sustainable harvest, salmon and steelhead must produce more adults than are needed for spawning. This means enough adults must be allowed to escape to spawn and perpetuate the run, and the **productive capacity** of the habitat must be maintained. Unfortunately, these prerequisites for sustainable harvest have been regularly violated in the past. The lack of coordinated management across jurisdictions, coupled with competitive economic pressures to increase catches or sustain them in periods of lower production, resulted in harvests that were too high, limiting the numbers of adults returning to spawn.

The objectives of the harvest options are to: manage fisheries to prevent overharvest and contribute to recovery; and provide fishing opportunities that comport with **trust obligations** to the tribes and comply with sustainable fisheries objectives for all citizens. These options presume that the harvest reforms of recent years will continue. The reforms, along with the dramatic decline in productivity, have already come at great cost to fishing interests in the Pacific Northwest, especially the tribes.

In the long term it is the United States' policy to provide harvest opportunities for the region's Indian tribes. For this reason, the hatchery and harvest options are closely related to provide for increasing the opportunities for harvest where there will be minimal impacts on **depressed stocks** of fish.

Option 1:
Fishery Benefits During Recovery

- This option implements the recently negotiated Pacific Salmon Treaty (PST) conditions in all ocean fisheries and, as contemplated in that agreement, further constrains U.S. fisheries south of Canada in some years if necessary to comply with the ESA. It would apply the constraints currently being developed for upper Willamette and lower Columbia **chinook** salmon. When abundance of **listed stocks** is similar to 1999, the in-river fisheries would be managed to limit impacts on listed summer chinook to 5 percent or less and on spring chinook to 7 percent or less. In-river fall fisheries would be managed so as not to exceed the 1999 **harvest rate** limits for Snake River fall chinook and **B-run** steelhead. In anticipation of higher abundance in the future, a schedule would be developed that allows harvest rates to increase as abundance increases.

Option 2:
Fixed In-river Harvest Rates (1999 levels)

- This option is the same as Option 1, except that no stepped in-river harvest rate schedule would be included. In-river fisheries would be managed to limit impacts on listed spring and summer chinook to 7 and 5 percent, respectively, or less, and the fall season fisheries would be managed so as not to exceed the 1999 harvest rate limits for Snake River fall chinook and B-run steelhead. All of these rates would be frozen until **recovery goals** are achieved.

Option 3:
Conservation Fishery Levels

- This option implements the recently negotiated Pacific Salmon Treaty conditions for Alaskan and Canadian fisheries, except that additional voluntary reductions would be sought in these fisheries. It differs from Option 2 in that all other harvest impacts on listed populations would be reduced to **conservation crisis levels** for a period of years, after which it would shift to Option 1 or 2. Conservation crisis levels are defined as levels similar to the 1999 harvest rates for listed spring/summer chinook (5 to 7 percent), and comparable conservation crisis levels for listed Snake River fall chinook and listed steelhead.

Hatcheries Options

Hatchery fish represent approximately 80 percent of the annual adult salmon and steelhead returning to the Columbia River Basin. Nearly all hatchery fish programs were intended to compensate for the loss of fish and fish habitat due to construction of the Federal Columbia River Power System (FCRPS). Modern hatchery production peaked in the early 1990s at over 200 million fish annually. Today there are about 100 anadromous fish hatcheries, including satellite facilities in the Columbia River Basin, and they produce about 150 million fish annually.

Chinook salmon are the largest salmon. Chinook are long distance swimmers and travel to the farthest reaches of the Columbia Basin to spawn. The fish return from the ocean to the Columbia River in the spring, summer and fall and are differentiated by the time of year they return, and the age at which they migrate to the ocean. **A-run steelhead** return to the drainage in the fall and spawn in small, lower elevation streams in the late winter and early spring. The larger-bodied **B-run steelhead** return in the fall or the spring and spawn in medium-sized, higher elevation streams from March to June.

A fish **run** is a group of fish of the same species that migrate together up a stream to spawn, usually associated with the seasons, i.e., fall, spring, summer and winter runs.

A **Biological Opinion** is a document stating the opinion of the U.S. Fish and Wildlife Service or the National Marine Fisheries Service on whether a federal action is likely to jeopardize the continued existence of listed species, or result in a destruction or adverse modification of **critical habitat**. The NMFS 1995 and 1998 Biological Opinions addressed how the federal dams in the basin should be operated to protect fish.

Hatcheries have a long history of providing fish in an efficient manner for harvest and related social purposes. It is not yet clear, however, whether hatcheries are effective in rebuilding self-sustaining, **naturally-spawning** populations over the long term. A fundamental question is: how can **artificial production** be applied in a manner that not only avoids harm, but also assists in the conservation and rebuilding of wild runs?

The four objectives for the hatchery options are to: minimize the adverse effects of hatchery production on wild fish; conserve genetic resources; help rebuild natural populations; and use hatcheries creatively to **mitigate** for lost fishing opportunities resulting from losses of habitat or reduced productivity.

Option 1:
Currently Planned Programs

- This option includes currently planned programs to conserve genetic resources and currently planned improvements in mitigation programs.

Option 2:
Increase Conservation Programs

- This option would increase programs to conserve genetic resources over the currently planned programs, and have the same currently planned improvements in mitigation programs, with corresponding reductions in overall production.

Option 3:
Increase Conservation Programs and Significantly Decrease Mitigation Programs

- This option would increase programs to conserve genetic resources, as described in Option 2, and significantly decrease mitigation programs below currently planned levels.

Hydropower Options

Hydropower development has had profound effects on the basin's salmon and steelhead runs, resident fish and other aquatic species. Grand Coulee Dam on the Columbia River mainstem and the Hells Canyon Complex on the Snake River blocked passage to over half of the salmon's historic upriver spawning areas. Many smaller dams on the tributaries have also blocked spawning areas. The hydropower system affects fish in other ways as well. The **storage reservoirs** behind dams in the basin alter natural streamflows and temperature patterns, and the dams themselves block or delay both upstream and downstream fish migration. The presence of the dams also may cause increased dissolved nitrogen gas from voluntary and involuntary **spills** and may alter natural temperature patterns which are important for fish habitat and migration.

Dam operators have developed several methods for moving migrating fish past the dams and reservoirs, including mechanical **bypass systems** and transporting juvenile fish in trucks and barges to release sites below Bonneville Dam. In addition, a **flow augmentation program** called for under NMFS' 1995 and 1998 **Biological Opinions** aims to restore more natural flow patterns during the time juvenile and adult salmon and steelhead are migrating. These and other changes have resulted in important survival improvements for migrating fish.

The hydropower options have two objectives: provide adequate survival and maintain **healthy** adult and juvenile anadromous fish inhabiting and/or migrating through the hydropower system; and provide instream and reservoir environmental conditions necessary to provide adequate survival of resident fish and other aquatic species.

The options represent the major choices in direction and strategy for the hydropower system. The goal was to try to determine how much improvement the region could realistically expect to see with these substantially different approaches, and how much difference it would make for the fish overall and in combination with actions in the other Hs. The Federal Caucus examined the option of removing Snake River dams, but not Columbia River dams because feasibility work has not been initiated for these dams.

We did not examine **configuration** options for Federal Energy Regulatory Commission (FERC)-licensed projects but recognize that changes at these projects may have benefits for fish. Opportunities for fish passage improvements at FERC-licensed projects should be considered during relicensing processes.

Option 1:
Current Program

- This option would continue on the present path of ongoing improvements to the system, with roughly the existing annual level of investment continuing into the future.

Option 2:
Aggressive Program

- In this option, we assume the current program for improved fish passage facilities, such as surface bypass, will be successful and will be implemented to increase passage survival. The primary difference in configuration measures between this alternative and the present program is that the federal agencies would seek increased funding to pursue more aggressive implementation of measures to improve passage survival. Flow **augmentation** (especially in the Snake River) and spill will be increased.

Option 3:
•Breach Lower Snake River Dams

- The final option we considered improves conditions for Snake River stocks by removing the dams that block their passage in the lower Snake River.

Biological Considerations

To construct integrated alternatives, the Federal Caucus considered the available scientific analyses. These include the Cumulative Risk Initiative (CRI), developed by the Northwest Fisheries Science Center of NMFS, and the Plan for Analyzing and Testing Hypotheses (PATH), a collaborative effort of state fishery agencies, tribes and federal agencies. NMFS is conducting analyses of upper Columbia ESUs in collaboration with states, tribes and others in the Quantitative Analytical Report (QAR). Preliminary analyses for upper Columbia River ESUs are currently under review, and analyses for other basin ESUs are underway. The Northwest Power Planning Council's (NPPC) Multi-Species Framework project is also analyzing biological effects of different actions, but these analyses are not yet available.

The CRI has estimated the risk that salmon and steelhead ESUs in the Snake River will reach a **quasi-extinction** threshold, defined as one fish or fewer returning in any single year. We have not attempted to lay out in this report what level of biological risk is "acceptable" in relation to the CRI results. In addition to extinction risk, the CRI examines what opportunities exist to improve survivals in different life stages and how such improvements might reduce the risk of extinction. This examination is based on theoretical survival improvements in different parts of the fishes' life cycle. Analyses have not yet been completed to determine whether such improvements are feasible.

The PATH analyses use life cycle models to project the likelihood that Snake River spring/summer chinook and fall chinook will meet certain survival goals within 24 and 100 years, and recovery goals within 48 years. The PATH results may be overly optimistic. PATH models show trends improving regardless of the management actions pursued.

Results of all modeling efforts should be used with caution as models contain many assumptions that might be wrong. Moreover, the farther out the projection, the less certain the results.

Snake River ESUs

Snake River spring/summer chinook are listed as threatened. They have a serious risk of reaching the quasi-extinction threshold in the short term, as high as 10 percent for some populations, and require a large improvement in productivity (about 12 percent, on average) to reduce that risk to more acceptable levels. Dam removal by itself is unlikely to achieve this improvement or lead to recovery of this ESU, unless there is significant indirect mortality associated with dam passage and/or transportation. The best prospects of avoiding short-term extinction and achieving recovery for this ESU appear to be combinations of action in habitat **restoration**, harvest limits, predator control, and hydropower improvements, including dam removal. With or without dam removal, harvest restrictions may be needed for many years.

Snake River fall chinook are listed as threatened. They have less than a 1 percent likelihood of reaching the quasi-extinction threshold in the short term, but a more serious risk of reaching that threshold over the long term (6-17 percent). They require a more modest increase in productivity of about 4 percent to have a more acceptable risk of reaching the quasi-extinction threshold. Such an increase might be achieved by removing dams or by dramatic cuts in harvest. However, harvest restrictions may need to continue over the long term, raising serious implications for exercise of tribal fishing rights and other harvest. Removal of lower Snake River dams would have the added benefit of potentially increasing available spawning habitat by as much as 70 percent.

Snake River steelhead are listed as threatened. They have a less than 1 percent likelihood of reaching the quasi-extinction threshold in 10 years, but their rate of decline has been so steep since 1980 that they are projected to have a greater than 90 percent likelihood of reaching that threshold in 100 years. To reduce this risk to a more acceptable level requires about a 10 percent increase in productivity. A long-term reduction in harvest rates to 5-10 percent might be sufficient to achieve this increase. However, harvest restrictions may need to continue over the long term, raising serious implications for exercise of tribal fishing rights and other harvest. Alternatively, removal of lower Snake River dams could also prove sufficient. It may also be possible to improve survivals through habitat and hatchery improvements.

Snake River sockeye are listed as endangered. They cannot be modeled because there are so few of them. They are now kept from extinction by a **captive broodstock program**.

Upper Columbia River ESUs

Upper Columbia River steelhead are listed as endangered. They are particularly complicated to model because they are maintained primarily through hatchery production. Steelhead have no significant likelihood of dropping below quasi-extinction levels so long as they continue to be sustained by hatchery production. Projections of future performance without hatchery production depend on assumptions about how effective hatchery fish have been at reproducing in the wild. QAR analysis indicates that assuming hatchery fish have been equally as effective as **naturally-spawning fish**, this ESU has a 100 percent probability of reaching a quasi-extinction level of two fish in one year within 41-72 years. Reducing this risk to 5 percent requires an improvement in productivity on the order of 35-42 percent, assuming recent environmental conditions continue into the future. Since work is ongoing, it is premature to draw conclusions about what actions may be required to recover upper Columbia steelhead.

Upper Columbia River spring chinook are listed as endangered. Detailed assessments of extinction risks are still being developed. Initial results, using methods similar to those employed in the CRI analyses, project high quasi-extinction risks for these runs in the absence of hatchery **supplementation**. Model results indicate that the supplementation programs being implemented to support these runs could reduce the risk of falling below quasi-extinction levels to negligible levels. Based on preliminary results, reducing the risk of quasi-extinction to below 1 in 100 at 100 years would require a 28-35 percent improvement in productivity in the absence of hatchery supplementation. Since work is ongoing, it is premature to draw conclusions about which actions may be required to recover upper Columbia chinook.

Other ESUs

The CRI is continuing model work on additional ESUs. Modeling should be completed for upper Willamette chinook and steelhead by early next year.

Integrated Alternatives

There are a number of ways to combine options from the different Hs to arrive at integrated alternatives. Those displayed are certainly not an exhaustive enumeration of all the possibilities. The alternatives are all intended to improve survivals of Columbia Basin salmon and steelhead populations over the long term, although some have more certain benefits than others. It was the intention of the Federal Caucus to display possible alternatives that have some likelihood of contributing significantly to recovery of listed populations.

A fundamental point made by these alternatives is that the Federal Caucus' assessment is that current levels of activities in the four Hs will be inadequate to provide significant confidence in salmon and steelhead recovery. From that basis, packages of measures have been arrayed to begin the discussion about how best to approach salmon recovery. The purpose of the alternatives is to further discussion and debate of these and other alternative combinations that have significant potential for contributing to recovery of salmon and steelhead populations.

> *The alternatives describe broad policy choices for salmon and steelhead recovery, and are intended to stimulate public discussion and allow the public early access to the thinking process within the Federal Caucus. They do not represent the only combinations of options that could provide recovery, nor do they represent preferred federal alternatives.*

Alternative A
Dam Removal

Habitat – Option 1
Coordinate and Prioritize Federal Actions
Harvest – Option 1
Fishery Benefits During Recovery
Hatcheries – Option 1
Currently Planned Programs
Hydropower – Option 3
Breach Lower Snake River Dams

Under this alternative, the decision is made now to breach Snake River dams and the necessary congressional authorizations are pursued. The primary reliance for recovering Snake River fish is on breaching. There is little increase in effort to improve habitat conditions on nonfederal land, as resources would be focused on dam breaching. Because of the expected benefit in fish productivity from breaching, harvest is constrained by **weak stocks**, but is allowed to increase as runs increase. Since most **conservation hatchery programs** are aimed at Snake River fish, there is no need to increase the conservation program, and existing resources would be shifted to the Columbia River ESUs. Similarly, the expected increase in productivity of wild Snake River fish means there is less concern about the possible harmful effects of mitigation hatchery production on wild fish in the Snake River. This alternative does not improve survivals for fish outside of the Snake River beyond those improvements that would result from programs already in place.

Alternative B
Harvest Constraints

Habitat – Option 1
Coordinate and Prioritize Federal Actions
Harvest – Option 3
Conservation Fishery Levels
Hatcheries – Option 3
Increase Conservation Programs and Significantly Decrease Mitigation Programs
Hydropower – Option 1
Current Program

Under Alternative B, the Snake River dams are not breached and the region relies instead on harvest constraints to recover fish runs, along with existing improvements in the hydropower system and improvements on federal habitat. All fisheries are held to conservation levels for a period of time (e.g., 10 years) to "jump start" recovery. Since fisheries are so constrained, it is logical to also reduce the production of **mitigation hatchery fish**. This reduction may provide further unquantifiable survival benefits to wild fish.

Alternative C
Aggressive Non-Breach

Habitat – Option 2
Coordinated Regional Plans
Harvest – Option 2
Fixed In-river Harvest Rates (1999 levels)
Hatcheries – Option 2
Increase Conservation Programs
Hydropower – Option 2
Aggressive Program

Alternative C defers a decision on dam-breaching and allows an interim period to determine whether aggressive action in all of the Hs (short of breaching) is likely to recover Snake River fish, and to resolve key scientific uncertainties. Hydropower actions include increased flows (especially in the Snake River) and increased spill. State and local governments contribute significantly to habitat protection (improved instream flows and water management; irrigation improvements; **riparian** protections, etc.) through state regulatory and voluntary programs. Additional populations are brought into hatchery conservation programs if necessary to prevent extinctions. Harvest is held at a flat rate based on 1999 fishing rates until stocks recover.

Alternative D
Maximum Protections

Habitat – Option 2
Coordinate Regional Plans with a default to Option 3 if increased states' and local efforts do not occur

Harvest – Option 3
Conservation Fishery Levels

Hatcheries – Option 3
Increase Conservation Programs and Significantly Decrease Mitigation Programs

Hydropower – Option 3
Breach Lower Snake River Dams

Alternative D is the most aggressive scenario, in which all Hs make dramatic contributions in an effort to recover listed stocks throughout the basin. The most risk-averse option within each H is pursued to maximize efforts to rebuild stocks and improve productivity. In the case of hatcheries, conservation programs would increase outside of the Snake River, and mitigation programs would be reduced basinwide.

Other Considerations

Several important points should be considered in evaluating the options presented, as well as others that might be possible:

Biological Evaluation

- How certain are we that an action will have the anticipated biological effect?
- How long will it take to realize the benefits of the action?
- How many ESUs will be benefited by the action?
- What is the status of the ESUs that will be benefited (threatened, endangered, important to tribal fisheries)?

Social and Economic Effects

- What effect will the action have on tribal social and cultural values?
- What effect will the action have on nontribal social and cultural values?
- What are the direct and indirect economic consequences of the action?

Ecological Effects

- What effect will the action have on the Columbia Basin ecosystem?
- What effect will the action have on other aquatic species?

Effects on Tribal Rights

- What effect will the action have on the tribal right to harvest fish?

Implementation

- **Can the action be implemented within** existing authorities, or are new authorities required?
- What entity (or entities) would implement the action, and is that entity willing and able to act?
- **How long will it take to implement the** action?

Performance Measures and Standards

Performance measures and standards are critical underpinnings of any management framework. They define the contribution that is needed at each life-history stage to achieve the overall biological goals and objectives, and they do so in context with the contributions from other life stages. A performance standard is the specific level of achievement that is required in a particular performance measure or metric. Its purpose is to establish the performance objective of a measure or action, achievement of which indicates the action has been successful.

The following principles should be used to guide the development of performance measures and standards:

- Performance measures and standards would be developed with consideration for impacts of habitat, harvest, hatchery, and hydropower actions (the four Hs), particularly on wild stocks.
- Performance measures and standards would be defined for all Hs.
- Performance standards for actions in each H could be based on the relative contribution to improved survival.
- Performance standards would be adjusted over time to reflect success or failure in achieving recovery.

Next Steps

In the months to come, the agencies that make up the Federal Caucus will be asking for public comment on the report and the options it presents. Beginning in January 2000, public meetings will be held throughout the region. The Northwest Power Planning Council has agreed to participate in this public process so that the Multi-Species Framework alternatives may be discussed at the same time. In addition, individual federal agencies will invite comments on other related federal processes including: the Snake River Feasibility Environmental Impact Statement (EIS); the Interior Columbia Basin Ecosystem Management Program (ICBEMP) EIS; and NMFS' ESA Section 7 consultation on operation and configuration of the Federal Columbia River Power System.

For More Information

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The Federal Caucus Web site:
www.bpa.gov/federalcaucus.

To request copies of documents:
Call 1-509-358-7415 or
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Comment Procedure

By mail:

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Introduction

Native salmon and steelhead, and many resident fish species are in decline throughout the Columbia River Basin. Recent analyses indicate that extinction risks for Snake River salmon and steelhead populations are significant. These analyses confirm that major changes must be made in a wide range of activities that cause harm to those stocks if salmon recovery is to be successful. Analyses for the remaining salmon and steelhead populations in the basin will be completed in a few months. Making changes to recover these fish will require all of the governments and people of the Pacific Northwest to confront tough choices. The success of salmon recovery in the Columbia Basin depends upon the willingness of the region to make those tough choices.

Populations, Stocks and Evolutionarily Significant Units

All designations of groups of fish are somewhat artificial. *Populations* are generally defined as a group of fish that interbreed when mature, and do not interbreed to a significant degree with other groups of fish. *Evolutionarily Significant Units (ESUs)* are groups of populations designated by NMFS for purposes of implementing the Endangered Species Act. ESUs are distinct groups of populations that typically occupy similar habitats, are genetically similar, and that represent an important component of the evolutionary legacy of the species. *Stocks* of fish are designated by managers generally for purposes of managing fisheries. In some cases, units identified by managers as "stocks" will be similar to populations. In a few cases, a unit identified as a "stock" will also coincide with a unit identified by NMFS as an ESU.

The deterioration of the Columbia's once-numerous fish runs can be traced to the economic development of the basin. The human activities that have caused the decline of these fish – often referred to as the "Four Hs" – are habitat, harvest, hatcheries, and hydropower. Forestry, agriculture, mining, and urbanization have altered or destroyed tributary *habitat*. Fishing, or *harvest*, has reduced the number of adult fish that return to spawn. *Hatcheries* have introduced inbreeding and competition, may have been a source of disease for **wild fish**, and have in some cases induced fisheries to harvest at rates too high for natural stocks. And *hydropower* dams on the Columbia and Snake rivers have blocked and inundated **mainstem** habitat, altered natural flows, impeded passage of migrating fish, and created a series of pools where fish predators reside.

Last year, nine federal agencies formed a *Federal Caucus* to examine opportunities the region has in each of the Hs for recovering listed salmon, steelhead and resident fish. Our intent was to develop a conceptual recovery plan that could guide future federal actions. This paper examines several of the basic options for future management in each of the four Hs. These options are not intended to be exhaustive. Using these options, the Federal Caucus developed a set of integrated alternatives, or packages of options, which mix and match the various options. These integrated alternatives are intended to illustrate the type of integrated strategies that will be required for successful recovery. They are not presented, however, as the exclusive set of packages that are possible. None should be viewed as preferred, and there are practical or legal obstacles to implementing some of the options, or integrated alternatives.

The purpose of this paper is to outline the fundamental choices that face the region if salmon recovery is to succeed. The objective is to stimulate an honest and constructive debate among the governments and the people of the region. That honest debate holds the best hope for a durable set of commitments by which to recover salmon stocks and the health of the rivers upon which they depend.

This document, and the regional dialogue it may stimulate, will be factored into other regional discussions scheduled for the near term (see box on page 12).

Other Related Processes in the Region

- *Northwest Power Planning Council and Multi-Species Framework Process.* The Framework seeks to link Columbia Basin fish and wildlife restoration policy to a basinwide vision, based on a scientific foundation that recognizes that the river and its species are interrelated parts of a whole. The Framework analyzes seven alternative visions, their benefits and impacts. The NPPC will base its Fish and Wildlife program amendments on one of the Framework alternatives. The NPPC rulemaking is expected to begin December 8, 1999 and be completed in July 2000.

- *U.S. Army Corps of Engineers' Lower Snake River Feasibility Study.* The Corps is preparing an environmental impact analysis that will review options for improving juvenile salmon migration in the lower Snake River. Breaching the four lower Snake dams is one of the options being studied. The product of this effort will be an Environmental Impact Statement (EIS) that will provide information for decision-makers who must ultimately decide on what measures are needed to recover Snake River salmon and steelhead runs. Many federal and state agencies are participating in this study.

- *Interior Columbia Basin Ecosystem Management Program (ICBEMP).* ICBEMP is a massive federal land-use plan that covers 144 million acres in Oregon, Idaho, Washington, Montana, Nevada, Utah, and Wyoming. Of this amount 72 million acres are currently under federal control and the other 72 million acres are private property, state, county and tribal lands. Its goal is to restore this area to a condition that will better support fish and wildlife.

- *Draft Biological Assessment on Operation and Configuration of the Federal Columbia River Power System (FCRPS).* The Biological Assessment is being jointly prepared by the Corps of Engineers, Bureau of Reclamation, and BPA. It is part of the consultation process, required by the Endangered Species Act, between NMFS and the three federal agencies that operate the FCRPS. The BA provides information regarding the impact of operation of the FCRPS on threatened or endangered species. NMFS will consider this information in the preparation of its Biological Opinion on the effects of the operation of the FCRPS on all listed salmon and steelhead in the basin.

- *Columbia River Basin Forum.* Formerly called The Three Sovereigns, the Columbia River Basin Forum is designed to improve the management of fish and wildlife resources in the Columbia River Basin. The process is an effort to create a new forum where the federal government, Northwest states and tribes could better coordinate, discuss and resolve basin-wide fish and wildlife issues under the authority of existing laws.

1. Existing Conditions

1.1 Physical Setting

The Columbia River Basin covers about 250,000 square miles in seven western states and British Columbia and is defined by unique geologic and water features. The states in the Pacific Northwest follow, in the most part, the basin's geographic features. See map below. An enormous variety of plants and animals occupy the wide array of physical habitats in the Columbia River Basin.

The Columbia River Basin

1.2 Species Status

The Columbia River Basin historically supported many anadromous species, including hundreds of populations of chinook, sockeye, coho, chum and pink salmon, as well as steelhead, coastal cutthroat trout, white and green sturgeon, eulachon, and Pacific lamprey. Fifty-two fishes, both anadromous and resident, are native to the Columbia River Basin, including 13 **endemic** species (McPhail and Lindsey 1986). Changes in the physical, chemical and biological condition of land and water bodies throughout the basin have dramatically affected the status of many of these fish. Dam development blocked, inundated and **segmented habitat** for anadromous and resident fish, and human development and activities have altered or destroyed much of the habitat that remains.

In the late 1970s, concern about the protection of fish species led to consideration of Snake River salmon stocks for listing under the ESA. In 1980 Congress passed the Northwest Electric Power Planning and Conservation Act, which created the Northwest Power Planning Council and charged it with developing a fish and wildlife program. Passage of that Act and creation of the Council led NMFS to withhold listing. In 1991, NMFS listed Snake River sockeye as endangered, followed closely by listings of Snake River spring/summer and fall chinook. NMFS has listed 12 Columbia River Basin salmon and steelhead Evolutionarily Significant Units (ESU) as threatened or endangered under the Endangered Species Act. The U.S. Fish and Wildlife Service (USFWS) has listed seven resident fish and other aquatic species as threatened or endangered. This section briefly reviews the status of the anadromous and resident fish populations remaining in the basin.

1.2.1 Anadromous Salmonids

Native salmon and steelhead are in decline throughout the basin. Some believe that 40 salmon stocks from Washington have become extinct during the last 150 years (Nehlsen, et al. 1991). Historically, 10-16 million salmon and steelhead returned each year to spawn, but by the 1960s, that number had dropped to about 5 million. Today, only about a million fish return, and most of them originate from hatcheries, not from the wild. Of the anadromous **salmonid** stocks in the Columbia River Basin, about 60 percent are listed as depressed, threatened or endangered. At least 65 native stocks have been **extirpated**.

In many cases, populations that appear relatively stable or with increasing numbers exist because they are composed mostly of hatchery fish. While nearly every **subbasin** has a salmon population that is in decline, populations in the uppermost portions of the basin are generally at higher risk or have suffered the greatest loss. For example, of the 12 salmonid ESUs listed under the ESA by NMFS, those classified as endangered occur in either the upper Columbia River (steelhead and spring chinook ESUs) or Snake River (sockeye ESU). These fish must go through or get around seven, eight or nine dams (four of them federal dams) during their upstream and downstream migrations. Below are brief summaries of the current state of anadromous salmonids in the Columbia River Basin. See box for more detailed information.

Salmonids belong to the family salmonidae, i.e., salmon, trout, steelhead, whitefish.

Extirpate - To destroy or remove completely, as a species from a particular area, region, or habitat.

Chinook Salmon – Chinook salmon have a relatively widespread distribution throughout the basin, however most populations are seriously depressed. The highest commercial catches occurred in 1883 when nearly 22,000 tons were harvested Fulton (1968). While some healthy chinook populations remain, most are depressed and many have already been extirpated.

Coho Salmon - Coho were once widespread and abundant in the Columbia Basin, but are now considered extinct in upper Columbia and Snake River drainages, and in serious decline in the remaining range in the lower Columbia River. Commercial catches in the 1920s peaked at greater than 700,000 fish landed (Fulton 1970).

Chum Salmon - Historically this species may have spawned as far upstream as the Walla Walla River, but today chum salmon are found in a handful of tributaries and stream **reaches** downstream of Bonneville Dam. The spawning areas lost (primarily due to hydropower development) are not extensive and represent only a small portion of the available habitat (Fulton 1970). Historically, the Columbia River had an abundant chum

Anadromous Species Status in the Basin

Chinook Salmon – Four ESUs are listed as threatened (Snake River fall-run, Snake River spring/summer run, Lower Columbia, and Upper Willamette River ESUs); one is endangered (Upper Columbia River spring run ESU). Of the 50 chinook stocks identified by Nehlsen et al. (1991), 3 were classified as of special concern, 3 at moderate extinction risk, 9 at high extinction risk, 5 possibly extinct, and 30 as extinct. Huntington et al. (1996) considered only two stocks as healthy - Hanford Reach fall chinook and Lewis River fall chinook runs. An assessment by Washington Department of Fisheries et al. (1993) identified 48 Washington chinook stocks, of which 1 was critical, 23 were declining, and 24 were classified as healthy. Oregon has also classified Snake River fall chinook and spring/summer chinook as threatened species under the state's ESA, while Washington has identified 4 populations (i.e., Washington chinook populations in ESUs listed under the federal ESA) as **species of concern** under the Washington ESA.

Coho Salmon – NMFS has tentatively identified a coho ESU that includes populations in southwest Washington and the lower Columbia River. This ESU is a candidate for ESA listing, however, it is unclear whether native, naturally reproducing coho still occur in the Columbia Basin. Nehlsen et al. (1991) classified nearly all coho stocks above Bonneville Dam as extinct. They considered the remaining lower Columbia stocks to be extirpated or at moderate to high risk of extinction. WDF et al. (1993) characterized all Washington stocks as depressed, and Oregon recently classified Columbia River coho as an endangered species under the state ESA.

Chum Salmon – NMFS has identified all Columbia River chum populations as a single ESU and recently listed them as threatened under the ESA. Nehlsen et al. (1991) listed the Umatilla and Walla Walla River stocks as extinct, and characterized all other Columbia River chum as being at moderate risk of extinction. WDF et al. (1993) classified two Washington stocks as depressed, and one as healthy, and the state of Washington has identified lower Columbia River chum as a species of concern under the state ESA.

Sockeye Salmon – There are at least three sockeye ESUs in the Columbia Basin, and one of these - the Snake River ESU - has been protected under the ESA since 1991. Washington has identified Snake River sockeye as a species of concern and Nehlsen et al. (1991) classified 17 stocks as extinct, one possibly extinct, one at high risk of extinction, and two of special concern. WDF et al. (1993) identified the Wenatchee and Okanogan stocks as healthy, while Huntington et al. (1996) considered only the former to be a healthy native stock.

Steelhead – NMFS has listed all five Columbia River ESUs as threatened or endangered under the ESA. The state of Washington has likewise included the Washington stocks on their list of species of concern, and of more than 30 stocks assessed by WDF et al. (1993), all but two (Kalama and South Fork Toutle River stocks) were described as depressed. Nehlsen et al. (1991) reviewed steelhead stocks throughout the basin and classified 11 stocks as extinct, 1 possibly extinct, 10 at high risk of extinction, 7 at moderate risk of extinction and 15 of special concern. These authors also considered all small-tributary stocks above Bonneville Dam to be at high risk of extinction, while small-tributary stocks below the dam were considered to be at moderate extinction risk. Huntington et al. (1996) identified five native stocks - all in the John Day River Basin - as healthy.

Cutthroat Trout – NMFS has identified one ESU that includes Columbia Basin populations (a southwest Washington/Columbia River ESU) and has proposed it for listing as a threatened species under the ESA. Many of these same Columbia Basin stocks were identified as of special concern or at moderate to high risk of extinction by Nehlsen et al. (1991). These authors also noted 2 stocks that have been extirpated in this ESU.

Pink Salmon - Although McPhail and Lindsay (1986) identified this species as native to the lower Columbia River, pink salmon are rarely encountered in the basin (Emmett et al., 1991). NMFS has identified two ESUs in the lower 48 states, both in Puget Sound and the Strait of Juan de Fuca.

population that supported annual harvests numbering in the hundreds of thousands. Current abundance is probably less than 1 percent of historic levels.

Sockeye Salmon **-** This species is dependent on lake spawning habitats principally located in the Snake and Upper Columbia River Basins. Historically, commercial catches in the Columbia River may have reached nearly 1.3 million fish in the 1890s (Fulton 1970), but current returns are probably in the tens of thousands of fish. Counts of Snake River sockeye spawners have not exceeded 8 fish during the past decade and the ESU is kept alive only through a **captive-breeding program**. Although sockeye salmon in the Upper Columbia Basin are not listed, their numbers are depressed.

Steelhead - Like chinook, steelhead spawning populations are still relatively widespread in the basin, however they too have undergone dramatic declines and local extinctions. Minimum run size estimates for Columbia Basin steelhead indicate that 150,000-450,000 adults returned during 1938-1967 (Fulton 1970). Current production estimates are in the tens of thousands, with the bulk of production coming from tributaries to the middle Columbia.

Coastal Cutthroat Trout - Commonly referred to as sea-run cutthroat, this species has a complex suite of **life history** types that include anadromous and resident types, as well as a freshwater migratory form.

Pink Salmon - Pink salmon are rarely encountered in the basin (Emmett, et al. 1991). NMFS has identified two ESUs in the lower 48 states, both in Puget Sound and the Strait of Juan de Fuca.

1.2.2 Resident Fish and Aquatic Species

Bull Trout **–** Historically, bull trout were widely distributed throughout the Columbia River Basin from the lower river to its headwaters. Bull trout are estimated to have once occupied 60 percent of the basin and now are estimated to occur in about 45 percent of their former range (Quigley and Arbelbide, 1997). **Fluvial** and **adfluvial** forms of migratory bull trout occur in the area of federal dams and both forms **spawn** and **rear** in tributary streams. The largest populations of bull trout in the FCRPS system are at the Hungry Horse and Libby projects. Bull trout are also present in Lake Pend Oreille (Albeni Falls project), in the lower Snake River, Lake Roosevelt, and in Bonneville pool.

Fluvial fish migrate to larger rivers to overwinter and feed in spring and summer; **adfluvial** fish reside in lakes and reservoirs.

Spawning is the act of reproduction in fishes.

Kootenai River White Sturgeon **–** The Kootenai River population of white sturgeon became isolated from other white sturgeon in the Columbia River Basin during the last glacial age (about 10,000 years ago). Once isolated, the population adapted to the predevelopment habitat conditions in the Kootenai River drainage. This white sturgeon population has been in general decline since the mid-1960s. In 1997, the population was estimated to be about 1,468 wild fish with few individuals less than 25 years of age. The population was listed as endangered in 1997.

Snake River Aquatic Species **–** The middle Snake River from C.J. Strike Reservoir to American Falls Dam provides habitat for the five Snake River snails listed as threatened (the Bliss Rapids snail) or endangered (the Snake River physa, Banbury Springs lanx, Utah valvata snail, and Idaho springsnail) under the Endangered Species Act. With the arrival of exploration and development, the Snake River ecosystem has undergone significant transformation from a primarily free-flowing, cold-water system to a slower moving and warmer system. At present, the listed species occur mainly in the remaining free-flowing reaches or spring alcove habitats of the Snake River.

1.3 Biological Requirements

1.3.1 Salmon and Steelhead

NMFS has defined the geographic boundaries of major stock groups or Evolutionarily Significant Units (ESUs) of Pacific Salmon throughout the West Coast that are genetically and demographically distinct from each other. Nineteen ESUs in the Columbia River Basin occupy four interconnected regions:

(1) Snake River Basin, (2) upper Columbia River Basin, (3) middle Columbia River Basin, and (4) lower Columbia River/Willamette River Basin.

Life-history traits, such as run-timing, vary among and within ESUs due to selection imposed by a variety of factors, including differing times of peak stream flow, seasonal barriers to passage (e.g., waterfalls), and differing migration distances. This diversity of life history traits has been important in maintaining the historic abundance of salmon in the basin.

Like all organisms, salmon have individual maintenance requirements. In fresh water, these include adequate water quality (including temperature and dissolved oxygen requirements), sufficient water quantity, adequate food supply, and appropriate spawning and rearing habitat. Different species and different life-history types vary in their specific requirements. For example, chum salmon require **low-gradient tributary habitats** near tidal areas in the lower basin for spawning, while sockeye salmon spawn in beach gravels in lakes in the interior basin. The degree to which the biological requirements of individuals are met will affect the **viability** of the entire population or ESU, by affecting the size, stability, spatial structure and diversity of the population.

A **low-gradient** stream or river has a slope of less than 0.02 percent.

Though biological requirements are different among species, there are essential features of salmon habitat for sustaining healthy salmon populations. Table 1 provides an overview of these features for each life stage of the salmon's life cycle. NMFS has developed a guidance document called the *Matrix of Pathways and Indicators* (MPI) that describes in more detail the freshwater habitat conditions for salmonids and includes an analytic methodology to help determine the environmental effects of various human actions on these habitat conditions (see box) (NMFS 1996).

For More Information:

Species status reviews prepared by NMFS summarize some of the available information for West Coast salmon, and good reviews of the available literature are contained in Everest et al. (1985), Bell (1986), Groot and Margolis (1991), Bjornn and Reiser (1991), Meehan and Bjornn (1991), and Spence et al. (1996). Many of the parameters and values described in the literature must be interpreted with caution; some are based solely on laboratory observations while others are based on field studies that may not be applicable to all species or locations.

Matrix of Pathways and Indicators (MPI)

MPI helps determine the environmental effects of various human actions on habitat conditions. The pathways for determining the effect of an action are represented as six conceptual groupings (e.g., water quality, channel condition, and dynamics) of 18 **habitat condition indicator**s (e.g., temperature, width/depth ratio). Default indicator criteria (mostly numeric, though some are narrative) are laid out for three levels of **environmental baseline condition**: properly functioning, at risk, and not properly functioning. The effect of the action upon each indicator is classified by whether it will restore, maintain, or degrade the indicator.

The MPI provides a consistent, but geographically adaptable, framework for determining the effect of various human activities on salmon and their habitats. The pathways and indicators, as well as the ranges of their associated criteria, are well-grounded in available scientific literature yet amenable to alteration through the process of **watershed analysis**. The MPI, and variations on it, are widely used in ESA section 7 consultations. The MPI is also used in other venues to determine baseline conditions, identify properly functioning condition, and estimate the effect of individual **management prescriptions**. This assessment tool was originally developed for forestry activities, but NMFS is working to adapt it for other types of land management, and for larger **spatial and temporal scales** such as those found in the Columbia River Basin.

Survival in the ocean also affects salmonid populations. Shifts in ocean conditions, brought about by shifts in climate, have produced abrupt differences in salmon survival in the ocean (Francis and Hare 1994). Although the mechanisms affecting ocean survival are largely unknown, they are presumed to be the result of annual and decadal variation in nutrient availability (and thus, in an upward cascade, algal and zooplankton production) (e.g., Hare et al. 1999). Recent modeling suggests that climate changes due to

Table 1 - Summary of Major Habitat Requirements for the Salmon's Life Cycle

Habitat Requirements	Habitat Concerns
Adult Migration Pathways Adult salmon leave the ocean, enter estuaries and rivers, and migrate upstream to spawn in the stream of their birth.	• Passage blockage (e.g., culverts, dams) • Water quality (high temperatures, pollutants) • Competition with exotic species High flows/ low flows/water diversions • **Channel modification**/simplification • Reduced frequency of holding pools • Lack of cover, reduced depth of holding pools • Reduced cold-water **refugia** • Increased predation resulting from habitat modifications
Spawning and Incubation Salmon lay their eggs in gravel or cobble nests called redds. To survive eggs (and the alevins that hatch and remain in the gravel) must receive sufficient water and oxygen flow within the gravel.	• Availability of **spawning gravel** of suitable size • Siltation of spawning gravels • Redd scour caused by high flows • Redd de-watering • Temperature/water quality problems • Redd disturbance from trampling (human, animal).
Stream Rearing Habitat Juvenile salmon may remain in freshwater streams over a year. They must find adequate food, shelter, and water quality conditions to survive, avoid predators, and grow. They must be able to migrate upstream and downstream within their stream and into the estuary to find these conditions and to escape high water or unfavorable temperature conditions.	• Diminished **channel complexity**, cover • Temperature/water quality problems • Blockage of access to habitat (upstream or down) • Loss of **off-channel** areas, wetlands • Low water flows/high water flows • Predation caused by habitat simplification or loss of cover • Nutrient availability • Diminished prey/competition for prey • Stranding due to water level fluctuations • Competition with exotic species
Smolt Migration Pathways Smolts swim and drift through the streams and rivers, and must reach the estuary or ocean when there are adequate prey and water quality conditions and must find adequate cover to escape predators as they migrate.	• Water quality • Low water flows/high water flows • Altered timing/quantity of water flows • Passage blockage/diversion away from stream • Increased predation resulting from habitat simplification or modification • Stranding due to water level fluctuations
Estuarine Habitat Estuaries provide a protected and food-rich environment for juvenile salmon growth and allow the transition for both juveniles and adults between the fresh and salt water environments. Adults also may hold and feed in estuaries before beginning their upstream migration.	• Water quality • Altered timing/quantity of fresh water in-flow • Loss of habitat resulting from diking dredging, filling • Diminished **habitat complexity** • Loss of channels, eel grass beds, woody debris • Increased predation resulting from habitat simplification • Diminished prey/competition for prey • Reduction/elimination of periodic flooding • Competition with exotic species

Source: Modified from Pacific Fisheries Management Council. 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and Identification of Essential Fish Habitat, Adverse Impacts and Recommended Conservation Measures for Salmon. Portland, OR.

A **smolt** is a salmonid or trout life stage between parr and adult, when the juvenile is at least one year old and has adapted to the marine environment.

doubled levels of atmospheric carbon dioxide would significantly alter coastal productivity, potentially affecting the growth, survival and distribution of salmon populations (Hinch et al. 1995, Welch et al. 1998).

In addition to suitable habitat conditions, salmonids depend on a variety of population characteristics that contribute to species persistence. Recently, NMFS has been developing an approach to describe viable salmonid populations (VSP) with the goal of providing guidance for determining the **conservation status** of populations and ESUs of Pacific salmonids. The concept and criteria presented are intended to both aid in the formulation of recovery plans and serve as interim guidance until such plans are completed. Initial recommendations for viability criteria are described as *rules of thumb*, which mix qualitative guidelines and quantitative values, depending on the parameter and the amount of information available. Some general tenets of this approach include:

Resident fish occupy headwater reaches; they may disperse locally, but generally they are not considered migratory.

- The populations that make up an ESU should be large enough and well-distributed enough to (a) survive changes in their environment similar in magnitude to past observed changes, and (b) maintain their **genetic diversity** over the long term.
- A population should be able to maintain enough *natural* productivity to continuously replace itself without the aid of hatchery subsidies — even in the face of poor ocean or freshwater habitat conditions. In addition, a population should not exhibit sustained declines or show a trend that would portend such declines.
- The spatial structure of the habitat patches upon which salmon depend (as well as the patches themselves) should be maintained. That is, there should be enough patches in proximity that natural stray rates may continue *and* there should be a wide enough distribution among the patches that localized catastrophic events have a low probability of driving an ESU to extinction.
- Human-caused factors such as habitat changes, **harvest pressures**, and **artificial propagation** should not substantially alter salmon diversity in terms of traits such as run timing, size, **fecundity**, **morphology**, behavior, and molecular genetic characteristics. This diversity *and* the genetic and environmental factors that engender it should be maintained.

Emergence - The process during which fry leave their gravel spawning nest and enter the water column.

Substrate is the composition of a streambed, including mineral and organic materials.

There is a great deal of uncertainty about the best way to evaluate population viability in terms of salmonid abundance, trends, productivity, spatial structure, and diversity. That uncertainty should be taken into account whenever viability analyses are being performed. While it is possible to describe in general what good habitat and population conditions are, we are still learning how human activities affect these fish, their habitats and the ecosystems within which they reside.

1.3.2 Resident Fish and Other Aquatic Species

Resident fish and other aquatic species in the Columbia River Basin have similar biological requirements as Pacific salmon (e.g., good water quality, access to habitat/cover and food, and opportunities to breed) and will benefit from many actions to improve habitat for salmon. However, specific biological requirements vary by species.

Bull Trout – Bull trout display a high degree of sensitivity at all life stages to environmental disturbances and have more specific habitat requirements than many other salmonids (Fraley and Shepard 1989, Howell and Buchanan 1992, Rieman and McIntyre 1993). Bull trout growth, survival, and long-term population persistence appear to be particularly dependent on five habitat characteristics: 1) cover, 2) channel stability, 3) substrate composition, 4) temperature, and 5) migratory corridors (Rieman and McIntyre 1993). Length and timing of incubation to **emergence** (200 days or more during winter and early spring), the strong association of juvenile fish with stream channel **substrates**, and a fall spawning period make bull trout particularly vulnerable to altered flow patterns and associated channel instability. Successful bull trout spawning and development of embryos and juveniles requires very cold water temperatures. Such strict temperature tolerances predispose bull trout to declines from any activity occurring in a watershed that leads to increased stream temperatures.

Extensive migrations are characteristic of the species and migratory bull trout facilitate the interchange of genetic material between populations, ensuring sufficient variability within populations. The disruption of migratory corridors, if severe enough, will result in the loss of migratory life history types and isolate resident forms from interacting with the **metapopulation**.

Kootenai Rive White Sturgeon – White sturgeon are broadcast spawners, releasing their eggs and sperm in fast water. Based on recent studies, Kootenai River white sturgeon spawn during the period of historical peak stream flows from May through July (Apperson and Anders 1991; Marcuson 1994). Spawning at peak flows with high water velocities disperses and prevents clumping of the adhesive eggs. Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature (Brannon et al. 1984). Historically, flows were often in excess of 60,000 cubic feet per second in the area below Bonners Ferry where the fish spawn. These annual flushing events re-sorted river sediments providing a clean cobble substrate conducive to insect production and sturgeon egg incubation. In addition, much of the Kootenai River has been channelized and stabilized from Bonners Ferry downstream to Kootenay Lake, resulting in reduced aquatic **habitat diversity**. Modification of the Kootenai River white sturgeon's habitat by human activities has changed the natural **hydrograph** of the Kootenai River, altering white sturgeon spawning, egg incubation, and rearing habitats. The result has been a reduction in overall biological productivity of the population.

Snake River Snails - Ecologically, the five listed species of Snake River snails share many characteristics, and in some locations two or more can be found sharing the same habitat. Their habitat requirements generally include cold, clean, well-oxygenated, flowing water of low **turbidity**. With the exception of the Utah valvata and possibly the Idaho springsnail, the listed snails prefer gravel-to-boulder size substrate. Despite these affinities, each of the five species has slightly different habitat preferences. The Idaho springsnail and Snake River physa are found only in the free-flowing mainstem of the Snake River. The Bliss Rapids snail and Utah valvata occur in both cold water springs or mainstem habitats, while the Banbury Springs lanx only occurs in cold-water springs. The fauna dependent on free-flowing reaches of the middle Snake River have been declining due to fragmentation of the remaining free-flowing habitats and deteriorating water quality. Factors that degrade water quality include reduction in flow rate, warming due to **impoundment**, and increases in the concentration of nutrients, sediment and other pollutants reaching the river.

A **meta-population** is a population composed of local populations that are linked by migrants, which allows recolonization of unoccupied habitat after local extinction events.

1.4 Institutional and Regulatory Context

Many laws, treaties and regulations affect anadromous fish and their habitats in the Columbia Basin, governing everything from reclamation projects to artificial propagation. The United States and Canada, nine federal agencies, five states (Oregon, Washington, Idaho, Montana and Alaska) and 14 Indian tribes have different **authorities** over fish or fish habitat. Treaties between the United States and Indian tribes guarantee the region's tribes a right to meaningful fisheries.

Fish habitat extends from small headwater tributaries to the Columbia River estuary, covering federal, state, private and tribal lands. Countless programs exist to maintain current uses of the river, change current uses of the river, exploit natural resources and conserve natural resources. Institutions range from local watershed councils and water districts to basinwide organizations such as the Northwest Power Planning Council and Columbia Basin Fish and Wildlife Authority (CBFWA). Some have observed that the lack of a unified restoration plan and coordination among efforts in the basin is one of the causes of decline of anadromous fish (Bevan, et al. 1994). The purpose of this document is to help the region develop a recovery plan that results in better regional coordination and a unified regional direction.

The nine federal agencies in the Federal Caucus that developed this paper have differing authorities and jurisdictions for salmon recovery:

- NMFS – ESA jurisdiction over anadromous fish; it also has a role regulating commercial and tribal harvests.
- USFWS – ESA jurisdiction over plants, wildlife and resident fish.
- BPA – markets electricity from federal dams; it also has a key role funding fish and wildlife mitigation.
- The Corps – operates federal dams and locks for multiple uses.
- USBR – operates federal dams for multiple uses.
- EPA – enforces the Clean Water Act.
- USFS – manage the national forest system/.
- BLM – manages public forests and rangeland.
- BIA – trustee for tribal and individual Indian lands and resources held in trust.

1.5 Tribal Obligations

U.S. v. Oregon is a case addressing treaty fishing rights in the Columbia River Basin. The signatories to the settlement are the United States of America acting through the Department of the Interior and the Department of Commerce; the Nez Perce Tribe; the Confederated Tribes of the Umatilla Indian Reservation; the Confederated Tribes of the Warm Springs Reservation; the Confederated Tribes and Bands of the Yakama Indian Nation; and the states of Oregon and Washington.

There is a unique and long-standing relationship between the U.S. government and the region's Indian tribes. The United States holds a **trust responsibility** to all tribes to protect tribal trust resources, including natural resources such as fish, wildlife, timber and water, and cultural resources such as burial sites. In treaties between some tribes and the U.S. government, the tribes reserved certain rights, including fishing rights, which have been adjudicated through court proceedings notably, *U.S. v. Oregon*. The main trust resource affected by the options in this report is salmon and steelhead, and the main tribal right affected is the right to fish. There are, however, other important trust resources and tribal rights that may be affected by some of the options in the report.

The federal policy with respect to tribal fishing rights, trust responsibility and the ESA is set forth in a July 21, 1998 letter from Terry Garcia of the U.S. Department of Commerce to Ted Strong of the Columbia River Inter-Tribal Fish Commission (CRITFC):

> It is the federal policy that the recovery of salmonid populations must achieve two goals:
> 1) the recovery and delisting of salmonids listed under the provisions of the ESA;
> 2) the restoration of salmonid populations, over time, to a level to provide a sustainable harvest sufficient to allow for the meaningful exercise of tribal fishing rights. Furthermore, the federal agencies see no conflict between the statutory goals of the ESA and the federal trust responsibility to Indian tribes. Rather, the two federal responsibilities complement one another…. Our statement of the twin goals for salmonid populations listed under the ESA recognizes that the United States, and all federal agencies, stand in a trust relationship with all federally recognized Indian tribes and of the responsibilities that flow from that relationship. Hence, we understand the importance of the federal government's efforts to allocate the conservation burden for salmonids listed under the ESA in such a way that, among other things, it does not discriminate against tribal fishing rights and is implemented in the least restrictive manner. Accordingly, the tribes may reasonably expect, as a matter of policy, that tribal fishing rights will be given priority over the interests of other entities, federal and nonfederal, that do not stand in a trust relationship with the United States.

In addition, the letter reiterates the responsibility of all federal agencies to consult with the Columbia Basin tribes:

> The federal agencies will continue to consult with all affected tribes on a government to government basis as provided for in the President's Memorandum on Government to Government Relations with Native Americans, April 29, 1994, and Executive Order 13084 on Consultation and Coordination with Indian Tribal Governments, May 14, 1998.

Because of the loss of habitat, and reliance on hatchery fish to sustain upper basin fish populations and fisheries, decisions about hatchery fish directly affect treaty Indian fisheries. The parties to *U.S. v. Oregon* are negotiating harvest and hatchery programs in hopes of developing an integrated fish management plan that addresses conservation under the Endangered Species Act while meeting trust obligations to the tribes. The Federal Caucus will look to that process to resolve the details of those production and harvest decisions. The negotiations in *U.S. v. Oregon* are ongoing, and the date for completion of a new plan is uncertain.

2. Conservation Goals, Objectives and Scientific Principles and Tools

2.1 Goals

To provide a scientific framework for salmon and steelhead conservation, we have developed the following goals for a regional unified plan for recovery. These goals were used to derive the objectives and strategies that follow, and to form the options for each H.

2.1.1 Conserve Species

Avoid extinction and foster long-term survival and recovery of Columbia Basin salmon, steelhead, listed resident fish, and other aquatic species. Protect and restore abundant, productive, widely distributed and biologically diverse naturally-spawning populations. Foster recovery to levels that can withstand reasonable harvest, the impacts of continuing human activities, and a range of climatic and ocean conditions.

2.1.2 Conserve Ecosystems

Conserve the ecosystems upon which salmon, steelhead, resident fish and other aquatic species depend. Protect and restore ecosystem processes that create high quality habitat (tributary, mainstem and estuary) and protect and restore high water quality for spawning, rearing and migration.

2.1.3 Assure Tribal Fishing Rights

Restore salmon and steelhead populations, over time, to a level that provides a sustainable harvest sufficient to allow for the meaningful exercise of tribal fishing rights. Until these restoration levels are achieved, provide tribal fishing opportunities that respect tribal culture and recognize treaty rights.

2.1.4 Balance the Needs of Other Species

Ensure that salmon and steelhead conservation measures are balanced with the needs of other native fish and wildlife species. Ensure the long-term persistence of self-sustaining, complex interacting groups of resident fish and other aquatic and wildlife species across their native ranges.

2.1.5 Minimize Adverse Effects on Humans

Implement salmon and steelhead conservation measures in ways that minimize their adverse human effects.

2.2 Objectives

The following objectives will require further development. Quantitative definitions of these objectives should be developed wherever possible. We have three categories of objectives: Biological, Ecological and Socio-Economic.

2.2.1 Biological Objectives

- Maintain current distribution of fish and aquatic species, and halt declining population trends within 7 years.
- Restore naturally sustained fish populations and establish stable or increasing trends in abundance in each subregion accessible to the fish and for each ESU within 25 years.
- Restore distribution of fish and other aquatic species in previously occupied areas within the species' native range within 25 years (except where fish passage is infeasible).
- Conserve genetic diversity and allow natural patterns of **genetic exchange** to persist.
- Restore salmon and steelhead population levels that support tribal harvest opportunities and selected local harvest opportunities for nontribal fishers.

2.2.2 Ecological Objectives

- Prevent further degradation of tributary, mainstem and estuary habitat conditions and water quality.

- Protect existing high quality habitats.
- Restore habitats on a priority basis.

2.2.3 Socio-Economic Objectives

- Select actions to restore and enhance fish and their habitat that achieve the biological and ecological objectives at the least cost.
- Mitigate for significant social and economic impacts and explore creative alternatives for achieving these objectives.
- Provide certainty of funding and implementation for strategies and actions.
- Coordinate restoration efforts to avoid inefficiency and unnecessary costs.

2.3 Scientific Principles

These principles, derived from various scientific reviews and recovery planning documents that have been developed for fish and wildlife recovery in the Columbia Basin, will be used to shape conservation and recovery plans and how they are implemented.

- Conservation of Columbia Basin fish and aquatic species must address all aspects of the ecosystem and the species' lifecycle.
- Conservation requires a network of diverse, high quality, interconnected habitats and high water quality. Natural systems functioning properly are necessary to restore salmon and steelhead.
- Conservation requires preservation of life history diversity, genetic diversity and metapopulation organization. These characteristics affect the response of anadromous and resident fish populations to both demographic variation and variation in climate and environment.
- Conservation requires re-establishment of the nutrient cycle provided by decaying fish carcasses, to effectively cycle nutrients from ocean to freshwater.
- Because human activity, development and population growth will continue, conservation depends on managing human impacts to achieve suitable ecosystem conditions.
- Technology and research should be used to achieve natural ecosystem conditions, not to replace natural functions.
- Salmon and steelhead populations can be evaluated based on abundance, productivity, population structure and genetic diversity.

2.4 Scientific Tools

Several ongoing technical efforts are currently assessing the impact of human-induced factors on declining salmonid populations, the conditions necessary for recovery, and potential effects of recovery efforts on those populations. This paper uses information from these and other studies to assess the risk of extinction for salmon and other species, and to determine the potential beneficial and adverse impacts of proposed changes in each of the four Hs. These efforts are conducted at different scales, and address different types of questions; these differences between the analytical efforts must be considered when interpreting (and applying) their results.

2.4.1 Population-based Tools

The **Cumulative Risk Initiative** (CRI), is an ongoing effort of the NMFS' Northwest Fisheries Science Center, that assesses population trends and the impact of various actions on those trends. First, the group analyzes data regarding the four Hs to assess the impact of these factors on salmonid population growth. Concurrently, the team assesses the risk of extinction and constructs population computer models for each species, using current PATH/CRI estimates of survivorships (survival numbers) for each life-stage of a species. These models can identify the times or stages at which changing survival rates will yield the largest impact on population growth rates. Follow-up work entails examining whether such changes in survival are biologically feasible and what management options will yield the best results. Finally, as conservation actions are implemented, NMFS, in collaboration with other regional scientists, will be engaging in ecological experiments to test hypotheses about the relationships between management actions in the four Hs and salmon populations.

This paper relies heavily on the CRI's projections of the risk that an ESU will reach a quasi-extinction threshold within 10 and 100 years. The quasi-extinction threshold is one fish or fewer returning in any one year. This is a useful tool for assessing the risk of not acting quickly to improve survivals, but this type of projection comes with some caveats:

- The quasi-extinction threshold of one fish in one year may not be sufficiently conservative.
- Neither the Federal Caucus nor any of the federal agencies individually have concluded that a particular risk of extinction (for example, 1 in 100) meets a particular statutory requirement.
- Having a particular risk of reaching the quasi-extinction threshold does not necessarily equate to recovery. The CRI's extinction projections do not project future abundance levels, nor have abundance levels been adopted as *recovery* levels for any of the ESUs (although NMFS did propose recovery levels for Snake River spring/summer chinook and fall chinook in its proposed recovery plan). Future work should include establishing recovery goals for all listed ESUs, and projecting abundance levels with current management actions and with proposed management actions.
- The projections become less certain the farther out in time they go. Projections of extinction risk over 100 years are highly uncertain.

A **Viable Salmonid Population** is an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction over a 100-year time frame.

This paper also relies on the CRI's analysis of how much survival improvements in different life stages will contribute to population growth rate. This is a useful tool for focusing regional efforts on management actions most likely to yield significant benefits, as well as the magnitude of change needed at each life stage. However, at this stage the CRI has only performed numerical experiments based on theoretical survival improvements. Some actions are more certain to lead to survival improvements than others (for example, harvest reductions versus reductions in **hatchery releases**). More work needs to be done to determine whether it is biologically feasible to achieve some of these theoretical improvements. The CRI has estimated the risk of reaching quasi-extinction thresholds for Snake River salmon and steelhead. Analysis for the remaining ESUs will be available by the end of this year or the beginning of next year.

The **Plan for Analyzing and Testing Hypotheses** (PATH) is a joint effort of several federal, state and tribal agencies designed to predict future salmon populations under a variety of hydropower system and other management actions. This model simulates salmon population trajectories under a wide range of "assumption sets." These assumptions correspond to a rate, or a parameter in the model, for which there are different hypotheses concerning the effect that a variety of factors have on survival. Evaluating the likely effects of management actions on salmon populations entails running 240 to 1,920 different sets of assumptions. The likelihood of a particular management action achieving survival or recovery standards is then evaluated. PATH analyses show which actions are most robust (least risky) due to uncertainties in the model.

The **Viable Salmonid Population** (VSP) effort is another ongoing project of the Northwest Fisheries Science Center. This work defines characteristics of salmonid populations that can be considered viable, or self-sustaining over the long-term (at least 100 years). It provides guidelines for defining populations as well as qualitative and quantitative rules of thumb for identifying those populations that can be considered viable. Finally, it offers guidelines for the number and distribution of populations within an ESU necessary for an ESU to be considered viable. These rules of thumb consider genetic and life history diversity, spatial structure, as well as population size and trends in productivity.

The **Quantitative Analytical Report** (QAR) is a report NMFS and other federal agencies, state fisheries agencies, tribes, and the mid-Columbia Public Utility Districts agreed to develop to analyze the effects of a proposed Habitat Conservation Plan on upper Columbia spring chinook and steelhead. The effort includes a workgroup that is setting recovery goals, and another that is analyzing present risks of extinction and the likelihood of achieving recovery goals under the actions proposed in the plan. The workgroup is conducting extinction analyses using different population models. It will use the same models to project the likelihood that populations will reach the recovery goal.

2.4.2 Habitat-based Tools

The **Ecosystem Diagnosis and Treatment** (EDT) analysis is an *expert system*, developed by the Northwest Power Planning

Council's Framework process, that organizes available information concerning the impact of habitat attributes on salmonid populations. With this approach, small, hydrologically-defined areas are described using habitat attributes. Knowledgeable experts, using all available information, define *rules* describing the effect of each of these attributes on salmonid survival at all life stages. Using these rules, the EDT analysis defines the productivity and capacity of a landscape. Analyzing management scenarios involves changing the appropriate habitat attributes in the appropriate areas, and engaging the expert-defined rules to assess the predicted productivity and capacity of the changed landscape.

The **Interior Columbia Basin Ecosystem Management Project** (ICBEMP) has also constructed an expert system. ICBEMP uses spatially-explicit habitat and population status databases to evaluate spatially-explicit predicted status of a population, elements and capacity of aquatic habitat, and the **biological potential** of a population. Predictions include influences on **population dynamics** that are not a direct effect of the habitat, such as genetic factors or migration rates from other populations. Computer models have been used to project habitat capacity and population status across the interior Columbia Basin from various habitat management scenarios. The models are specifically designed to inform decisions about risks to habitat, options for managing risks to habitat, and spatial priorities for habitat restoration efforts. The models do not predict population size. ICBEMP analyses will be a primary tool for evaluating management actions on federal lands in the Columbia River Basin.

Finally, the **Northwest Fisheries Science Center** is conducting analyses designed to associate habitat characteristics at the watershed or **subwatershed** level with salmonid productivity. This effort examines physical attributes of subwatersheds, such as topography, geology, and distribution of channel types, as well as land use characteristics, such as the proportion of the area that is forested or urbanized, or the condition of riparian zones. These habitat characteristics are then associated with salmonid production information to identify the characteristics of habitats that are most productive. These analyses can be used both to identify subwatersheds that are currently important in maintaining current populations (and therefore may have a high priority for conservation), and to identify those subwatersheds for which restoration efforts have the greatest potential to yield large results.

2.4.3 Other Tools

Several analytical methods with a smaller scope than those outlined above have also been used to address particular risks salmonids face during their life cycle. In particular, SIMPASS was used to model the effects of different hydropower system configurations on downstream survival. In addition, several models of harvest effects, including those devised by the Technical Advisory Committee to the *U.S. v. Oregon* process, were used to identify the impact of levels of harvest on different stocks.

In the near term, qualitative evaluations will be the primary tool used to evaluate impacts and expected outcomes of proposed actions for listed resident fish and aquatic species. Quantitative data are limited for these species and models have not been developed to evaluate impacts and assess outcomes of actions.

3. Range of Options for Each H

In this section we describe the range of options we considered for each H. We had three purposes in developing these options:

- Consider solutions or actions that had not yet been explored,
- Test the **sensitivity** of different populations to changes in survival in different life stages brought about by actions in the different Hs, using the CRI approach other analytical methods, and
- Stimulate regional dialogue on the tradeoffs and uncertainties involved in selecting a suite of actions to recover the basin's salmon and steelhead populations.

For each H we describe briefly how it has contributed to the decline of listed species in the basin, what measures have been taken to mitigate for its effects, and the present status of those efforts. We describe a range of options and why we believe each is worth considering. Using quantitative and qualitative information, the report evaluates the options relative to the goals – to what extent does each option:

- prevent extinction (biological evaluation)
- and minimize adverse effects on humans (social and economic evaluation)
- conserve ecosystems and balance the needs of other species (ecological evaluation)
- assure meaningful tribal fishing rights (evaluation of harvest opportunities).

We relied on existing information from a variety of sources to conduct these evaluations, including the CRI, PATH, EDT, Fish and Wildlife Service Coordination Act Report, ICBEMP EIS, the Corps of Engineers' Lower Snake River Feasibility Study and the Multi-Species Framework Project. Our review of impacts other than biological impacts is cursory. These other impacts will play a significant part in any options finally chosen. Inadequate time was available, once the options were formulated, and many options are not sufficiently specific, to adequately analyze their economic, social, and cultural impacts. Nor did we analyze and recommend mitigation measures for the various options. Such information will be necessary to inform any long-term decision. We also discuss implementation issues, focusing primarily on the need to have a coordinated basinwide approach. We also present performance measures that would appropriately apply to a program for that H.

The following options are intended to represent broad choices in direction and strategy for each H. They do not represent exact prescriptions of actions and measures that would ultimately be implemented as part of an overall recovery plan. Specific actions and measures presented in this paper or in related documents are for illustration purposes only.

There are options beyond these, some of which are being examined in the Multi-Species Framework Project. No measures are proposed in any of the Hs that are less protective of salmon and steelhead than those currently in place, although we did test the sensitivity of some populations to increased impacts in different life stages. Additional detail on the options is included in appendices.

***Appendices** are available on the Federal Caucus Web site: www.bpa.gov/federalcaucus. You may also request copies of the appendices by calling 1-509-358-7415.*

3.1 Habitat

3.1.1 Overview

The quality and quantity of freshwater habitat in much of the Columbia River Basin has declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydropower development, mining and urbanization have radically changed the historical habitat conditions of the basin (see Maps 1 and 2). With the exception of fall chinook, which generally spawn and rear in major river channels, tributaries to the Columbia and Snake rivers provide habitat for salmon and steelhead spawning and rearing. Anadromous fish typically spend from a few months to three years rearing in freshwater tributaries. Depending on the population, anadromous fish spend from a few days to a year or two in the Columbia River estuary before migrating out to the ocean. Salmon and steelhead spend one to four years in the ocean, then return as adults to spawn in their **natal streams**. Thirty-two subbasins in the Columbia River provide spawning and rearing habitat (see Habitat Appendix).

This section addresses Columbia Basin tributary and estuary habitats of salmon and steelhead and some aspects of mainstem habitat. Mainstem habitat is primarily addressed in Section 3.4, Hydropower. Although this section focuses on anadromous species, the decline of habitat throughout the basin has affected many other species. Watershed improvements for salmon and steelhead and resident fish will benefit other aquatic, wildlife and plant species as well.

3.1.2 Contributions to Decline

There are many factors contributing to the habitat decline in the basin. Some of the more significant factors are described below.

Water quality in streams throughout the Columbia River Basin has been degraded by human activities such as dams and diversion structures, water withdrawals, farming and grazing, road construction, timber harvest activities, mining activities and urbanization. Over 2,500 streams and river segments and lakes do not meet federally-approved, state and tribal water quality standards under the **Clean Water Act** (CWA), and are now listed as **water quality limited** under section 303(d) (see Maps 3 and 4). Tributary water quality problems contribute to poor water quality in the mainstem. Sediment and contaminants from the tributaries may settle in the mainstem reaches and the estuary.

Temperature alterations have a major impact on salmon and steelhead, affecting metabolism, growth rate, disease resistance and timing of adult migrations, **fry emergence**, and **smoltification**. In Oregon and Washington most waterbodies, and in Idaho many waterbodies, on the 303(d) lists do not meet water quality standards for temperature.

There are many causes for high stream temperatures, but they are primarily related to land use practices rather than to **point source discharges**. Some common actions that result in high stream temperatures are the removal of trees or shrubs that directly shade streams, and excessive withdrawal of water for irrigation or other purposes combined with warm irrigation return flows. Loss of **wetlands** and increases in **groundwater** withdrawals have contributed to lower **base stream flows** which in turn contribute to temperature increases. **Channel widening**, and land uses that create shallower streams also cause temperature increases.

Pollutants degrade water quality. Salmon require clean gravel for successful spawning, egg incubation and emergence of fry. Fine **sediments** clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs. ***Excess nutrients, low levels of dissolved oxygen, heavy metals, and changes in pH*** also directly affect the suitability of waters for salmon and steelhead.

Water quantity problems are also a significant cause of habitat degradation and reduced fish production. Millions of acres of land in the basin are irrigated. Although most withdrawn water eventually returns to streams from agricultural **runoff** or from ground water recharge, crops consume much of the water. Withdrawals affect seasonal flow patterns by removing water from streams in the summer (mostly May-September) and restoring it to surface streams and ground water in difficult-

The **Clean Water Act** establishes water quality standards and regulates discharges of dredged or fill material into the waters of the United States.

Smoltification is the physiological change anadromous salmonids and trout undergo in freshwater while migrating toward saltwater that allows them to live in the ocean.

A **natal stream** is the stream of birth.

Maps 1 and 2 are found in Section 8, Maps.

to-measure ways. Withdrawing water for irrigation, urban and other uses can increase temperatures, **smolt travel time**, and sedimentation. Runoff from irrigation can introduce nutrients and pesticides into streams and rivers.

On a large scale, human activities have affected the timing and amount of peak water runoff from rain and snowmelt. Forest and range management practices have changed vegetation types and density on the land, which can affect timing and duration of runoff. Many riparian areas, **flood plains** and wetlands that once stored water during periods of high runoff have been developed. Urbanization paves over or compacts soil, and increases the amount of runoff reaching rivers and streams.

Many tributaries have been significantly depleted by water diversions. Fish and wildlife agency, tribal and conservation group experts estimated in 1993 that 80 percent of 153 Oregon tributaries had low-flow problems (two-thirds caused at least in part by irrigation withdrawals) (Oregon Water Resources Department 1993). The Council showed similar problems in many Idaho, Oregon and Washington tributaries (NPPC 1992).

Blockages that stop the downstream and upstream migration of fish exist at many agricultural, hydropower, municipal/industrial, and flood control dams and barriers. Highway culverts not designed for fish passage also block upstream migration. Migrating fish are diverted into unscreened or inadequately screened **water conveyances** or turbines, resulting in unnecessary mortality. While many fish passage improvements have been made in recent years, manmade structures continue to block migrations or kill fish throughout the basin.

Land ownership has played a part in habitat and land use changes (see Maps 5 and 6). Federal lands, which comprise 50 percent of the basin, are generally forested and influence upstream portions of the watersheds. While there is substantial habitat degradation across all ownerships, in general, habitat in many headwater stream sections is in better condition than in the largely nonfederal lower portions of tributaries (Doppelt et al. 1993, Frissell et al. 1993, Henjum et al. 1994; Quigley and Arbelbide 1997). In the past, valley bottoms were among the most productive fish habitats in the basin (Stanford and Ward 1992, Spence et al. 1996, ISG 1999). Today, agricultural and urban land development and water withdrawals have significantly altered the habitat and how fish and wildlife use these areas. Streams in these areas typically experience problems with high water temperatures, sedimentation, low flows, simplified stream channels and reduced riparian vegetation.

Mainstem habitats of the Columbia, Snake and Willamette rivers have been impacted by series of impoundments for mainstem and other multipurpose projects. These impoundments have inundated large amounts of spawning and rearing habitat. Historically, fall chinook salmon spawned in mainstem reaches from near The Dalles, Oregon, upstream to the Pend Oreille and Kootenai rivers in Idaho, to the Snake River downstream of Shoshone Falls and from the mouth of the Snake River to Grand Coulee Dam. Current mainstem production areas for fall chinook are mainly confined to the Hanford Reach of the Columbia River and to the Hells Canyon Reach of the Snake River, with minor spawning in the mid-Columbia, below the lower Snake River dams, and below Bonneville Dam. Hanford Reach is the only known mainstem spawning area for steelhead. Chum salmon habitat in the lower Columbia has also been inundated.

The mainstem habitats of Columbia, Snake and Willamette rivers has been reduced, for the most part, to a single channel, flood plains have been reduced, **off-channel** habitat features have been lost or disconnected from the main channel, and the amount of large woody debris (large snags/log structures) in rivers has been reduced. Most of the remaining habitats are impacted by flow fluctuations associated with reservoir management.

The Columbia River estuary has also been changed by human activities. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream and a shallow bar at the mouth of the Columbia River kept the environment dynamic.

Today, navigation channels have been dredged, deepened and maintained, jetties and pile dike fields have been constructed to stabilize and concentrate the flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to 2 miles and increased the depth of the Columbia River channel at the Bar from less than 20 to more than 55 feet. Sand deposition has extended the Oregon coastline, at the mouth, approximately 4 miles seaward and the Washington coastline, at the mouth, approximately 2 miles seaward (Thomas October 1981).

More than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreation, agricultural or urban uses (Lower Columbia River Estuary Program 1999). More than 3,000 acres of **inter-tidal marsh** and spruce swamps in the estuary have been converted to other uses since 1948 (Lower Columbia River Estuary Program 1999). Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed.

Dam construction and operation upstream of the estuary has changed the seasonal patterns and volumes of discharge into the estuary. The peaks of spring-summer floods have been reduced and the amount of water discharged in winter has been increased.

3.1.3 Current Management

Federal, state and local governments have responded to declining salmon runs with a host of habitat programs. In the long term, current programs are designed to prevent degradation of existing habitats and achieve needed high quality habitat across federal land.

Federal programs and authorities affect habitat on both federal and nonfederal lands. For example, on federal lands, the federal land management agencies (BLM and Forest Service) manage timber harvest, grazing, road construction, mining and recreation. Through **PACFISH**, **INFISH** and the **Northwest Forest Plan** they have vastly improved their land management practices to protect aquatic habitat by adopting strict standards that regulate these land management activities. They have also instituted restoration programs to fix problems created by past land use practices and are developing a long-term ecosystem strategy known as the Interior Columbia Basin Ecosystem Management Project (see Section 2.4.2). ICBEMP will replace PACFISH and INFISH interim aquatic conservation strategies with landscape and watershed level approaches that address broad ecosystem issues in the basin: the decline of salmon and other species; poor forest health leading to catastrophic fires; and the expansion of noxious weeds on degraded rangelands.

In the main channel in the estuary, the Corps dredges and maintains the shipping channel and is proposing a navigation channel-deepening project. There are potential substantial adverse effects resulting from this action, for example the creation of dredge spoils islands where Caspian terns and other birds nest. These birds prey on juvenile salmon. NMFS and USFWS are presently in consultation with the Corps on the navigation channel dredging. The goal of consultation is to substantially reduce these impacts immediately.

On nonfederal lands, there are a number of federal programs that either regulate activities or are aimed at restoring habitat. For example, the Corps issues dredge and fill permits and permits for water withdrawal structures in navigable waterways. The Bureau of Reclamation (USBR) provides technical assistance to states, tribes, irrigation districts, and others to consolidate diversions, improve irrigation efficiencies through water conservation and application and measurement technologies, and improve fish passage and protective facilities including fish screens and ladders. The Federal Emergency Management Agency (FEMA) requires local land use ordinances that regulate or prohibit land use development in flood plain areas. The Federal Energy Regulatory Commission (FERC) licenses nonfederal hydropower development. All these federal programs are subject to Section 7 consultation under the ESA, which provides a means to ensure that any programs

Under the Endangered Species Act, **take** means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect an animal, or to attempt to engage in any such conduct.

authorized, funded or carried out by federal agencies are designed to protect listed fish.

The USFWS and NMFS also implement a Habitat Conservation Plan (HCP) program under Section 10 of the ESA that provides certainty to landowners that their actions will not cause illegal **take** of listed species. These HCPs have amounted to thousands of nonfederal acres put into long-term conservation plans. A list of HCPs completed and underway in the Columbia Basin is in the Habitat Appendix.

There are also federal programs that provide incentives, particularly funding and technical assistance, to help land and water users protect and restore aquatic habitat. The Habitat Appendix contains a complete description of federal conservation programs in the Columbia Basin.

State and local regulations and programs have a pervasive effect on land and water use in the basin. A wide variety of state and local governments and agencies authorize and manage urban development, flood plain development, building construction, stormwater runoff, sewage treatment, water withdrawals, industrial pollution, agricultural pollution, forest practices, agricultural practices and rangeland practices. In addition, the Idaho, Oregon, and Washington water resources agencies have adopted limited, temporary moratoria on new water diversion permits from sensitive salmon streams. The extent to which state and local regulations and programs protect fish and their habitats varies widely from state to state and within states. There is also considerable variation in the extent to which state and local governments enforce existing regulations. Lack of enforcement may be due to inadequate funding and staffing or to a lack of political will where enforcement may be controversial. (This may also be true of federal programs.)

Nonfederal programs with the mission to conserve aquatic habitats have flourished in the last few years. The Nez Perce, Umatilla, Warm Springs and Yakama Tribes developed Wy-Kan-Ush-Mi Wa-Kish-Wit *Spirit of the Salmon*; Oregon has developed the Oregon Plan for Salmon and Watersheds and has awarded almost 200 grants totaling $10 million to assist with nonfederal habitat actions. In 1998, Washington enacted the Watershed Management Act, which provides that $4.5 million per year can be appropriated to set up partnerships, conduct assessments and fund actions that help the state's water resources and fish habitat needs. Also, Oregon and Washington fund jointly with EPA approximately $600,000 annually for the Lower Columbia River Estuary Program. Fueled by state initiatives such as these, literally hundreds of watershed partnerships have begun. Montana, Idaho, Washington and Oregon have developed strategies and plans for bull trout conservation and restoration.

There is significant effort invested in incentive-based habitat restoration. Increased efforts have been made in the last few years to coordinate state, local, and federal programs to protect and restore habitat. However, at the local level where most actions must occur, many watershed recovery efforts are diminished by a lack of technical assistance in planning, implementation and monitoring. Further, there has been insufficient coordination of recovery goals and standards. Lacking these, it is not possible to track how salmon and steelhead survival have benefited from these efforts.

Furthermore, most of the emphasis has been on restoring degraded habitat, which is important, but does not carry with it the weight of enforcement to halt continued degradation from land and water use. The human population in the basin will continue to increase, along with demands on water, land, and other resources. Habitat conditions on nonfederal land will continue to degrade unless there are significant improvements in land and water use. Without a combination of effective regulations and policies, voluntary efforts, and equitable incentives for private landowners, fish habitat conditions will continue to decline.

3.1.4 Habitat Program Objectives

There are three Program Objectives for habitat:

- Prevent further degradation of tributary and estuary habitat conditions and water quality.
- Protect existing high quality habitats.
- Restore degraded habitats on a priority basis.

Achieving these objectives would not result in fully restoring historic quantity and quality of habitats. However, these objectives contemplate that no population should go extinct (ESUs are comprised of multiple populations). To meet these objectives would mean substantial changes in land and water use in major portions of the Columbia Basin on nonfederal lands. The manner for and likelihood of meeting these objectives may vary depending on the status of the salmon, steelhead, and/or bull trout population and area.

3.1.5 Habitat Strategies

Strategies are presented for achieving the objectives.

1. Strategies that prevent further degradation of tributary and estuary habitat conditions and water quality include:

- ***Eliminate imminent risks to aquatic habitat and fish survival.***

Further degradation and loss of aquatic habitats will increase the declining trend of imperiled species. Imminent risks to aquatic habitat and fish survival must be eliminated through careful identification and implementation of projects that address imminent risks. For example, avian predation of migrating juvenile salmonids in the Lower Columbia River is an imminent risk to salmonid survival. Another example is a road at risk of failing and delivering sediment into fish habitat. Other examples include dry streambeds caused by water withdrawals, failed culverts, and passage barriers. See the Habitat Appendix for further details on identifying projects that eliminate imminent risks.

- ***Modify activities that present pervasive or long-term risks to habitat and water quality.***

Many land and water use activities create pervasive or long-term risks to aquatic habitat and water quality. Examples of such activities include: continued water withdrawal from streams with inadequate flows for fish, development in flood plains, increases in impervious surfaces in watersheds, timber harvest that reduces proper function of riparian areas, and urban and agricultural practices in riparian and upland areas that influence aquatic habitat.

2. Strategies that protect existing high quality habitat, and restore habitats on a priority basis include:

- ***Use multi-scale assessments to guide and prioritize actions.***

Assessments of populations and habitats at multiple scales are needed to identify opportunities for and risks to improved species survival. Site-level actions that measurably improve survival need to be determined within the context of ESUs and watersheds. Without this multi-scale context provided by assessment, site-level actions will often yield questionable results that cannot be related to improvement of the species survival. This multi-scale framework allows for broad-scale coordination while maintaining locally driven restoration efforts. See the Habitat Appendix for further details on multi-scale assessment, planning, and implementation.

- ***Develop and Implement action plans that produce measurable benefits***

Watershed action plans should be developed and implemented based on multi-scale assessments. Broad scale objectives should be used to guide local planning efforts that determine priority actions for securing and restoring habitat. Technical assistance provided by state, tribal, local or federal agencies will be critical in choosing protection and restoration actions that match the local watershed conditions and produce measurable benefits for imperiled aquatic species. See the Habitat appendix for further details on action plans and prioritization criteria that address multiple scales.

- ***Survey and adaptively implement measures to improve mainstem habitat diversity, complexity and productivity.***

Salmonids use and response to changes in the mainstem Columbia River are not well understood. Historically, fall chinook used large portions of the mainstem for spawning and rearing, and other salmonids may have used the mainstem for spawning and rearing as well. . Restoring potential hot spots of productivity in the mainstem could play an important role not only in salmon recovery generally, but in meeting tribal and other harvest objectives. Very little is known about what actions should be taken and where actions should be taken to improve habitat. Without this knowledge, prioritizing actions is difficult. To improve mainstem habitat, we must first survey existing mainstem habitat, then we can develop an implementation plan that will test promising approaches to mainstem habitat improvements, while maximizing opportunities to learn.

Various ways to restore or create the complex web of channels and other features in smaller rivers that once were part of the mainstem habitat have been suggested and some of these may be applied in the mainstem habitat implementation plan:

- create shallow-water habitat by excavating backwater sloughs, alcoves, and side channels and other measures;
- explore ways to stabilize reservoir levels;
- add large woody debris to these systems;
- re-connect alcoves, sloughs, and side channels to the main channel;
- establish emergent aquatic plants in shallow water areas;
- re-establish or enhance historic or existing wetlands;
- mimic natural hydrographs to the extent practicable;
- dredge or excavate lateral channels that have silted in;
- acquire and protect a belt of lands adjacent to the mainstems.

Site-level actions must be determined at a watershed scale and may be located in upland or riparian and aquatic areas, wherever is needed to address the causes of the problems. Actions will address one or more of the following ecological indicators: habitat quality, habitat quantity, water quality, water quantity, riparian quality, riparian quantity and biological communities. The draft NPPC Multi-Species Framework alternatives (NPPC 1999) identified a number of strategies that address these ecological indicators. These strategies are akin to desired ecological characteristics and will require a variety of site-level actions, both in the watershed and along the stream, to achieve. Specific strategies might include (derived from the draft NPPC Multi-Species Framework alternatives):

- Establish riparian and upland area conditions that provide the full set of functions needed to maintain water and habitat quality that will support native aquatic species, achieved mainly through **natural regenerative processes**.
- Establish **instream flows** in tributaries that reflect natural seasonal flow patterns.
- Re-connect instream aquatic habitats via the removal, modification or circumvention of physical or biological impediments (e.g., culverts, diversion structures, highways, high temperatures) to passage.
- Re-connect stream channels, flood plains, and wetlands such that inundation and **water table elevation** is consistent with naturally functioning patterns.
- Improve water quality through watershed habitat improvements and compliance with federally approved state and tribal water quality standards.
- Establish **sediment regimes** (input, storage, transport) consistent with those under which the aquatic ecosystem evolved.
- Restore natural patterns of woody debris recruitment through management of riparian areas as late successional forests.
- Restore physical stream habitat including **bank configuration**, habitat diversity and complexity that can support native aquatic communities.
- Restore natural biological communities in tributary streams such that they exhibit natural predator/prey relationships.
- Restore estuarine conditions that provide for adequate prey production, cover and habitat complexity for both smolts and returning adults.
- Restore quantity and quality of shallow water estuarine habitats (e.g., wetlands and marshes, tidal channels, submerged aquatic vegetation) to those that will support natural aquatic communities.
- Restore estuarine flow, sediment, and nutrient levels to those that support natural aquatic communities.

- Restore estuarine temperature, turbidity, bacteria, dissolved oxygen and gas and **salinity concentrations** that support natural aquatic communities.

Protection and restoration of aquatic and riparian habitats are also a function of having healthy watersheds and proper upland management on agriculture, forestry and urban lands. Strategies to ensure these watershed connections would include:

- Soil and water conservation practices that control erosion and runoff in order to reduce stream sedimentation, flooding, and bank erosion and those that help to maintain or improve base streamflows.
- Nutrient and pest management practices needed to limit delivery of pollutants that create eutrophic or toxic conditions for fish and other aquatic organisms.
- Vegetative practices that provide suitable cover to control erosion and runoff as well as provide food and shelter for wildlife.
- Wetland restoration and management practices that help maintain stream flows, filter pollutants, and provide flood storage.

There is a vast array of ecological and social conditions in the Columbia's watersheds. Site level actions for meeting the objectives and strategies should, in most cases, be determined through science assessments and coordinated local planning. Agencies and tribes have prepared several documents that provide extensive guidance for planning and implementing site-level actions. These documents are identified in the Habitat Appendix. The Habitat Appendix also suggests a framework for assessment and planning that leads to targeted site level action.

3.1.6 Habitat Options

The habitat options are different from options in the other Hs in that they do not identify specific sets of actions, primarily for two reasons. First, population and habitat science assessments are needed to determine the potential value of improving freshwater habitat and the quantity and distribution of habitat necessary for species recovery. Second, absent habitat assessments, it is not possible to determine all the site-specific actions needed in the Columbia Basin. Moreover, there is great variety in ecosystems and resource across the basin. Decisions on local actions are more appropriate at the local level, if they are made in the context of what the species need and in the context of overarching goals and objectives for the basin. The options for habitat provide strategic implementation choices and focus on the roles and responsibilities of various governments rather than on specific action items for specific locales.

Three basic options were developed for habitat. Option 1, Coordinate and Prioritize Federal Actions, includes moderate increases in efforts to protect and restore habitat, a measurable increase in federal action and coordination, and increased habitat assessments and planning efforts using federal funds. Option 2, Coordinated Regional Plans, increases state, tribal, local, and federal entities coordination, planning and habitat implementation. Federal funding would increase for habitat assessments, plans, actions, and monitoring. Option 3, Increased Federal Role under Clean Water Act and ESA, has similar components to Option 2, except it includes increased regulation by the federal agencies under the CWA and ESA.

The habitat options were developed using important assumptions about federal lands. Current federal land management under the Northwest Forest Plan, PACFISH, and INFISH and future federal land management strategies developed through ICBEMP should ensure restoration and recovery of habitat that will provide a foundation for long-term conservation and recovery of listed salmon, steelhead and trout. Activities implemented on federal lands should maintain conditions necessary to prevent further long-term degradation of aquatic habitat and water quality. Strategies to maintain conditions and reduce short-term and long-term risks to aquatic habitats will be developed through **multi-scale** science-based assessments and planning. Federal land management strategies are expected to protect and restore a network of high quality habitats, including riparian conservation areas essential to listed species recovery. Future land management strategies will be adjusted, if necessary, to incorporate new information on listed species. If these assumptions are met, federal lands are likely to meet the habitat program objectives.

Adaptive management - Feedback based on knowledge or data generated by monitoring and evaluation actions, of the effects or results of an implemented action. The information and data are purposefully collected and used improve future management plans and actions.

The habitat options then result in a range of outcomes *on nonfederal land*. They are intended to stimulate regional dialogue on how much effort different governments, agencies and stakeholders are willing to apply to habitat protection and restoration. This question includes the strength of the commitment of different governments to effectively regulate activities that degrade habitat; the degree to which different governmental entities, landowners and stakeholders are willing and able to participate in coordinated assessments, planning, and priority actions; the level of funding the region wants to commit to habitat protection and restoration; and the strength and scale of voluntary conservation efforts. These options focus on anadromous fish but should also be applicable to resident fish.

The habitat options assume that salmon populations will benefit from increased effort to make ecological change in watersheds and habitats. There are three basic components in each option that describe intensity of effort to make ecological change: level of coordination, level of comprehensive (voluntary and regulatory) effort, and level of funding. All options assume that in the next 5-7 years, the federal agencies would allocate funds to programs that:

- implement immediate actions (as described in the Habitat Appendix);
- reduce imminent risks to fish and their habitats;
- secure known important habitats;
- provide immediate (within three years from implementation) improvements in survival;
- are part of a strategic prioritized plan based on science assessment; and
- include monitoring.

Where needed, substantial funds over the next 3-5 years will go to assessments and planning. After this, most assessments and plans in the basin should be done and funding would go mostly to on-the-ground actions (prioritized through assessments) and monitoring. The bulk of prioritized habitat recovery actions would be completed in the next 10-15 years.

In developing and implementing these options, a number of considerations are important for success. Decisions should be based on measurable objectives, sound science, and **adaptive management** to provide real results over time. Decisionmaking must be participatory, with an emphasis on local implementation, innovation, and responsibility. Incentives for compliance and respect for existing rights should be stressed. In addition, options must acknowledge existing watershed efforts and build on their successes.

Coordination with existing watershed efforts will be particularly important for streams listed as water quality limited under section 303(d) of the CWA. Preparation of Total Maximum Daily Loads (TMDLs) and TMDL implementation plans for these streams is already underway in Idaho, Oregon, and Washington, based on priority lists compiled by the states. Under all of the habitat options, preparation of TMDL implementation plans should be coordinated with watershed assessments and priorities designed to satisfy the ESA.

Option 1

Coordinate and Prioritize Federal Actions

Under this option, there would be moderate increases in efforts to protect and restore habitat. The federal agencies would focus on federal land management, federal immediate actions and on improved coordination of federal funding for nonfederal actions. Federal lands would be managed to meet the assumptions described above. Immediate actions would reduce imminent risks and immediately improve survival. Improved coordination would include increased habitat assessments and planning that guide priority actions using federal funds. The rationale for this option is that increased federal coordination and coordinated assessments and planning prior to all but immediate actions would lead to increased measurable success of protecting and restoring important habitats.

This option does not seek significant new commitments from state, tribal and local governments. However, it would build on existing watershed efforts wherever available.

Level of Coordination

Increased federal coordination: The federal agencies would agree on basinwide protocols for population assessments, establishment of recovery goals, subbasin and watershed assessments, planning, coordinated actions, funding and monitoring. Once priorities for subbasin and watershed assessments, planning and actions are established, federal programs and dollars would be directed at these priorities.

Level of Comprehensive Effort

Federal land management agencies and the other federal agencies would participate in coordinated assessment, planning and priority actions. Federal land management agencies' programs and funds would be directed toward assessment and planning priority actions on federal lands. Federal land management agencies would participate in and invite nonfederal agencies and stakeholders to participate in assessment and planning. Other federal programs and funds (BPA, NRCS, EPA, USDA/FSA) would be directed toward assessments and priority actions on nonfederal lands that factor in assessments and activities for federal land. State, tribal and local governments and agencies would continue with present programs and levels of coordination and regulatory and voluntary efforts. They would continue to emphasize state, tribal and local restoration programs.

Level of Funding

Levels of funding would increase at a low rate.

Option 2

Coordinate Regional Plans

Under this option, state, tribal, local, and federal entities would significantly increase their level of coordination and comprehensive effort. There would also be an increase in federal funding for habitat assessments, plans, actions and monitoring. State, tribal, and federal entities would participate in coordinated plans and would implement coordinated priority actions. State and local governments would ensure effective regulations and programs that avoid further habitat degradation on nonfederal lands. Since habitat actions recommended for a particular watershed would be determined by an assessment that had local participation, local participants would be able to see a direct correlation between the regional habitat recovery plan and their local efforts.

The rationale for this option is that science-based assessments and coordination of priorities across all ownerships will be more effective at securing and restoring aquatic habitats. In addition, state and local governments are most likely to be effective in preventing further degradation of habitat because they have the relevant authorities.

Level of Coordination

A regional coordination mechanism including states, tribes, and federal agencies would ensure use of science-based basinwide protocols for population assessments, establishment of recovery goals, and completion of subbasin and watershed assessments, action plans, and monitoring. Once priorities for assessments, planning, and actions are established, federal, state and local programs and dollars would be directed at these shared priorities.

Level of Comprehensive Effort

The federal agencies will pursue two areas of action for mainstem habitat. First, the federal water development agencies would fund and support surveys and studies of potentially productive mainstem habitat. Second, federal agencies would implement, in cooperation with state, local and tribal governments, an adaptive program of mainstem habitat improvements. This work would proceed in accordance with a systematic, experimental management framework.

All necessary agencies, groups and landowners would participate in coordinated assessment and planning and would take actions based on shared priorities.

State, local and tribal governments would ensure that regulation of nonfederal activities is adequate to arrest downward habitat trends on nonfederal lands, beginning with water use and water quality. Where authorities, regulations or implementation are inadequate, state and local governments would propose means to fix the problems. Also, state and local governments would examine their effectiveness at enforcing and implementing existing rules and regulations. The federal regulatory agencies would put the present level of effort toward enforcing the ESA and CWA.

Level of Funding

Levels of federal funding would increase measurably, to complete immediate actions and coordinated federal/nonfederal assessments and planning within 5-7 years. federal funding to the states would increase, if possible, to speed up TMDL development and implementation plans, to enhance participation by the private sector and to bolster the states regulatory programs.

Option 3

Increased Federal Role under Clean Water Act and ESA

Option 3 emphasizes regulatory compliance with the requirements of the ESA and the CWA. Option 3 would be implemented if and when the region cannot develop the coordinated plan with state and local governments envisioned in Option 2.

This option has similar components to Option 2, except it includes increased regulation by the federal agencies under the CWA and ESA. This would occur if state and local governments do not ensure adequate programs to avoid further degradation. In this case, the federal regulatory agencies would increase federal regulation of nonfederal activities to arrest continued degradation of aquatic habitat. This option includes state, tribal, local and federal participation in coordinated assessment and planning as provided in Option 2.

The rationale for this option is that if state and local governments do not adopt and implement a recovery plan that includes adequate regulations, the federal agencies must exercise ESA and CWA regulation and enforcement authorities to ensure no further degradation of aquatic habitat.

This option is likely to be less effective at arresting continued degradation than Option 2. Habitat protection, maintenance and improvement objectives would have a lower likelihood of being met across all land ownerships due to the lack of participation by state, tribal and local entities in the development of common plans.

Level of Coordination

The level of coordination would likely be similar to levels of coordination under Option 1.

Level of Comprehensive Effort

The level of comprehensive effort would likely be similar to levels of coordination under Option 1.

The federal agencies will pursue two areas of action for mainstem habitat. First, the federal water development agencies would fund and support surveys and studies of potentially productive mainstem habitat. Second, federal agencies would implement, in cooperation with state, local and tribal governments, an adaptive program of mainstem habitat improvements. This work would proceed in accordance with a systematic, experimental management framework. Federal regulatory efforts would increase to ensure that nonfederal land and water use would not continue to degrade fish habitat. This would occur through a combination of increased ESA rule development, increased ESA enforcement and increased CWA enforcement.

Level of Funding

Levels of federal funding would increase to complete immediate actions and coordinated assessments and planning. Allocation of federal agency funds to enforcement and regulation would increase. Levels of federal funding passed through to the states would increase, if possible, to speed up TMDL development and implementation plans and to bolster the states' regulatory programs.

3.1.7 Evaluation of Options

Biological Evaluation

The habitat options will affect species survival in freshwater spawning and rearing, and estuarine rearing life stages. These generally encompass salmonid life-cycle years one through three, and also the life stages that include the use of estuaries and near shore ocean habitat. The evaluation considers effects on freshwater spawning and rearing but excludes effects of mainstem migration and hatchery influences. In the case of resident fish, the habitat options will affect all life stages.

The habitat options provide a range of implementation effort for avoiding further degradation of and improving habitat capacity. At the basin scale, we can identify a suite of premises and make some reasonable conclusions on the likelihood of successfully achieving the habitat objectives under each option. One premise is that the higher the effort for meeting the ecological objectives, the higher the likelihood and feasibility that we can improve survival of listed species in freshwater and estuarine life. Another premise is that coordinated assessment and planning will result in targeted priority actions that are most likely to achieve timely benefits.

A more detailed analysis of the role of habitat recovery and how recovery efforts should be focused to achieve the habitat objectives will be conducted during recovery planning focusing on ESUs. The CRI analysis is underway for a few ESUs (see box for species-specific early results).

The feasibility of gaining survival improvements in freshwater habitat will need to be determined on an ESU-by-ESU basis in two steps. The first step is to assess landscape level habitat characteristics associated with salmonid productivity and then determine the effect of land uses on those characteristics. Second, the social and economic potential and limitations will be important in determining the feasibility of meeting the objectives. There is a range of options and distribution for the level of effort on nonfederal lands, therefore it is useful to look at the amount and distribution of federal and nonfederal land ownership in the watershed to evaluate the options' likelihood of achieving the habitat objectives.

Other Considerations

Social and Economic Effects

It is difficult to evaluate the social and economic impacts of the different habitat options because they represent procedural options rather than action options. Habitat actions are generally local and site-specific. The social and economic impacts will accordingly be localized, and will vary depending upon the specific mix of actions taken and mitigation available in a specific area. The Habitat Appendix presents some examples of costs for habitat restoration projects that have been undertaken in the basin. Little work has been done to examine the social effects of different habitat options. The Northwest Power Planning Council's Multi-Species Framework Analysis has identified some costs for habitat improvements (see box).

In addition to the Northwest Power Planning Council's framework analysis cost estimates, the Federal Caucus developed a cost estimate related to the implementation of the Habitat Program Objectives that protect

Early CRI Results

Snake River Steelhead, Spring/Summer Chinook, Fall Chinook, Sockeye

A first step in prioritizing management actions is determining when in the salmon lifecycle there is potential to impact population growth rates, and where in the landscape those efforts might best be directed. Early results from the CRI analyses indicate that substantially reducing mortality during freshwater rearing or in the first year of estuary/ocean life would have a large impact on annual population growth rates. However, since a large portion of the mortality that occurs at these life stages is natural, an important next step will be determining the biological feasibility of achieving reductions in mortality during these life stages. Preliminary habitat (H-VSP) analyses in the Salmon River Basin indicate that the subwatersheds with the high productivity of spring/summer chinook are in areas with low water temperature, high quality riparian habitat and relatively low gradient. This analysis will be expanded to include the entire Snake River Basin. Examining the distribution and ownership of subwatersheds with these characteristics (or the potential to have them) will be an important element in determining where actions should be targeted as well as the most appropriate level of coordination for habitat actions in this basin.

Upper Willamette River Chinook and Steelhead

Analyses of **landscape-level characteristics** associated with levels of salmonid productivity are currently being conducted, and are scheduled to be complete by May 2000. Determining the distribution and ownership of areas with the potential for high productivity will be a critical element in prioritizing actions and determining necessary levels of coordination for improving salmon populations trends.

Framework Analysis of Habitat Effects

The Northwest Power Planning Council's Multi-Species Framework Analysis has identified some possible costs associated with habitat improvements. Habitat strategies aim to improve conditions for fish and wildlife through land management, restoration of normative stream characteristics, or passage improvements. Many habitat strategies would affect land use, or they have the potential to affect land uses that rely on water or land adjacent to streams.

The Framework analysis investigated the costs of six types of habitat strategies: 1) Habitat/water use on agricultural lands; 2) Screening of irrigation diversions; 3) Habitat on forest lands; 4) Riparian/instream habitat; 5) Blockage removal to improve passage; 6) Other habitat actions.

Habitat costs consist of the costs of economic activities impaired or eliminated plus implementation costs. Most habitat costs in the Framework study were not quantified. Costs for some strategies were identified only as scalable unit values, i.e., $/unit of habitat improved. However, in these cases, the intensity of the strategies was not identified, i.e., the number of units proposed for improvement was not quantified. The Framework process did provide the following estimates of habitat costs:

Costs associated with changes in agricultural and water uses. Habitat costs resulting from changes in these uses are mostly unknown, but could be large, depending on intensity of the strategy. Lease of irrigated land could cost between $100-$300 million annually. An additional $10-$100 million might be spent annually for screens, modified agricultural practices and agricultural land lease/acquisition. Year 2000 proposals to the NPPC for projects affecting habitat/water use on agricultural lands call for spending approximately $60 million in this area, and $7 million for screening of irrigation diversions. Washington State projects spending approximately $1 million in these two areas.

Costs associated with changes on forest lands. Reductions in timber harvest and increased costs for restoration and management on federal lands could be $100 million annually in costs and net revenue losses. Any costs for changes on private lands (unquantified) would be in addition to these. Year 2000 proposals would spend $1.6 million in 2000 for projects on forest lands.

Costs for riparian/instream habitat restoration. No costs were estimated in the Framework analysis. Year 2000 proposals to NPPC would spend nearly $10 million on such improvements in the year 2000. Washington State has proposed $4.5 million for these initiatives.

Costs for blockage removal to improve passage. No costs were estimated in the Framework analysis. Year 2000 proposals to NPPC would spend over $5 million on this in 2000, with the state of Washington spending over $3 million.

Costs for other habitat measures. Year 2000 proposals would spend an additional $41 million on

and restore habitat. Costs were estimated or assigned based on historical data or professional judgment of those working in the habitat field. Results of this analysis are very preliminary, and the Federal Caucus seeks comments on its approach. The approach and detailed results are included in the Habitat Appendix.

These preliminary results suggest that, on average, $3.0 million per year per subbasin over the near term is a reasonable basinwide approximation that would contribute to achieving habitat objectives. Through 2015, this would result in a total investment of about $3.0 billion. This total dollar figure includes $120 million per year to that already available for ongoing Conservation Reserve Enhancement Program (CREP) funding.

Any estimate of habitat costs should be viewed with caution. Not all subbasins are the same and some have greater needs than others. Actual needs and opportunities can only be determined after subbasin assessment and planning. It is likely that several data gaps have introduced a considerable amount of uncertainty into both the Federal Caucus and the NPPC estimates.

Ecological Effects

For the listed salmon, the habitat options provide a range of implementation effort for avoiding further degradation of habitat and improving habitat capacity. Resident fish and other aquatic species located in the same watersheds should also benefit from habitat actions focused on the recovery of the salmon ESUs, with the greatest benefit occurring under the options with the higher level of effort. The amount and scope of the benefit will depend upon the specific actions implemented in each watershed.

Effects on Tribal Rights

Generally, improvements in habitat will have a positive effect on tribal fishing and other natural resources. It is not possible to quantify the level of benefit to tribes, although in some cases it could be significant.

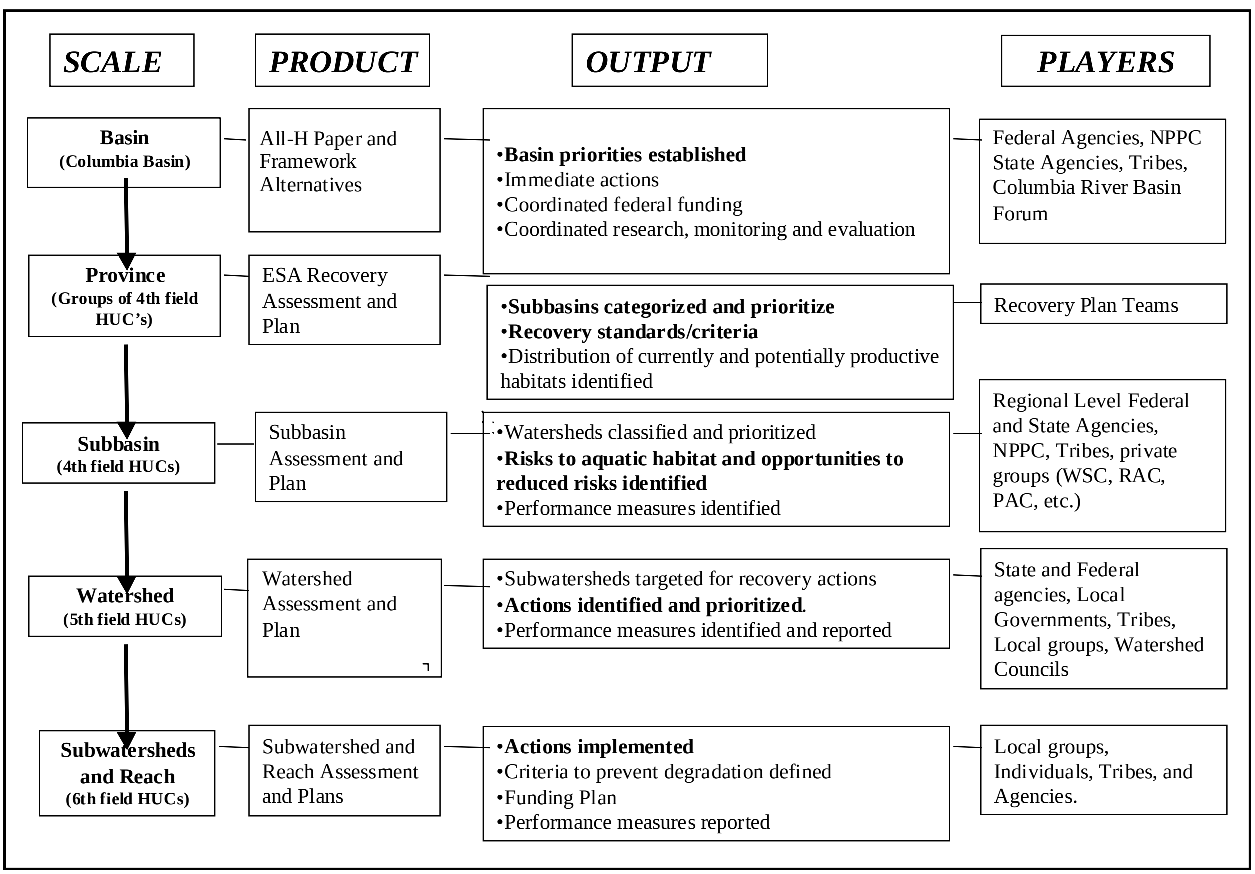
3.1.8 Implementation Issues

Widespread aquatic habitat recovery requires intensive local efforts that are prioritized and coordinated at larger watershed scales. In many Columbia River watersheds, ecosystem processes that maintain high quality conditions have been disrupted, setting in motion a downward trend in habitat conditions. Uncoordinated, quick fixes aimed at symptoms rather than causes will not reverse the downward trend. The following discussion proposes a coordinated multi-scaled, watershed-based assessment and planning process that integrates all institutional levels in watershed restoration and recovery. Figure 1 illustrates this roadmap to habitat recovery.

A multi-scaled approach coordinates, prioritizes, and tailors actions to locations in a manner that measurably achieves objectives with the least cost. Assessments and plans described in this section are already underway in a number of subbasins and watersheds. These ongoing efforts, including state-sponsored preparation of TMDL implementation plans under the CWA, should be used and built upon. The effectiveness of existing watershed efforts would be measurably improved through basinwide use of coordinated procedures.

This approach has the same three components at each scale: 1) immediate actions; 2) assessments using scientific protocols; and 3) action plans.

Figure 1 - Roadmap to Habitat Recovery



Implement Immediate Actions

For the most part, governments should commit scarce resources only to those projects that have been identified as important through an assessment that follows science-based procedures. Some actions, however, are so clearly necessary or beneficial they do not require an in-depth assessment.

State, local and federal governments should review and enforce existing laws and regulations to ensure that they are adequate to prevent further aquatic degradation. States should ensure full compliance with TMDL schedules and ensure that TMDL implementation plans also meet habitat requirements for listed salmonids. State, local and federal outreach on the Conservation Reserve Enhancement Program needs to be coordinated and improved. Protecting and improving streamflows is an immediate priority. Existing state moratoria on new water use should remain in place. Federal agencies should ensure that water conveyances and diversions that they permit do not deplete streams of flows needed for fish. These actions are further described in the Habitat Appendix.

Certain categories of site-specific actions should also proceed immediately. Site-specific actions would need to meet one of the following criteria: 1) the action is necessary to reduce imminent risk to the ESU or its habitat; 2) the action will secure high quality or productive habitats; 3) the action will result in immediate (within 5 years) and certain improvement in fish survival; and/or 4) the action is part of an already completed plan based on science assessment of fish habitat priorities. The Habitat Appendix addresses these criteria more fully.

Categories of actions that meet the criteria for immediate action include **road treatments**, water purchases and leases to enhance instream flows, fish screens fixing passage impediments, culvert and bridge replacement, water diversion consolidation, **push-up dam** removal or replacement, and removal of low-head dams. Also, ongoing efforts to protect or improve aquatic habitats on federal lands by modifying grazing, timber harvest, mining and other land management activities will continue. A sample of specific federal agency actions that meet the criteria is described in the Habitat Appendix.

Conduct Habitat Assessments using Scientific Protocols

Habitat assessments are needed at several scales (i.e., **province**, subbasin, watershed, reach).

At the basin scale, an interdisciplinary science team should lead the development of a protocol and sequence for mainstem habitat surveys and studies (for the Columbia, Snake and Willamette) below migration barrier dams.

There are a number of assessment procedures in use, or under development in the Columbia River Basin. A common approach to assessments across the basin is needed, and could be provided by a set of core elements at each scale. These common elements would be incorporated in all assessment procedures. A framework for developing protocols for the habitat assessments is in the Habitat Appendix. A key issue is who should be responsible for developing protocols, reviewing assessments for quality and ensuring a common database. This is a labor-intensive job and needs to happen as soon as possible.

Develop Action Plans and Implement Actions

To meet the three habitat objectives, multi-scaled action plans must use habitat assessments to:

- establish area goals and objectives;
- establish area priorities;
- identify opportunities for collaboration among area stakeholders;
- establish guidance for coordinating funding;
- identify and implement assessment or actions (depending on the scale); and
- establish performance measures and guidance for coordinated research, monitoring, and evaluation.

Ideally, the multi-scaled planning process would begin at the province scale where goals and objectives would incorporate ESA-listed species recovery criteria, and be clearly linked with recovery criteria, actions planned and implementation at finer watershed scales. However, many subbasin and watershed plans are already underway and will be completed before recovery criteria are established. Once recovery criteria are established, the assessments and plans should be reviewed, and if needed, adjusted. The region would establish recovery goals for all anadromous ESUs within two years, and the first habitat assessments and plans would be completed within three years. A framework for developing action plans is in the Habitat Appendix.

How federal land management agencies and others would use subbasin planning needs to be clarified, but criteria for subbasin and watershed plans will be an important component of the ICBEMP EIS and Record of Decision. Just how goals, objectives, priorities, performance measures, etc. would be developed has not been determined. A common planning process, accessible to state, local and tribal participants, must be organized and facilitated by some entity. All plans must also have a quality review before they are funded and must meet area priorities. Because there are not enough resources to go everywhere immediately, priorities based on logical criteria are needed. Logical criteria for prioritizing actions are needed at each scale: the basin, the province (groups of ESUs), the subbasin, and watershed (population). Prioritization criteria should be based on several considerations, including: ESUs that are most at risk, ESUs that could benefit most from improved habitat, tribal trust obligations, and habitats with the most potential for improved fish production. The status of existing assessment and plans, including state selected priorities for establishment of TMDLs, should also be considered. Examples of program priority criteria applicable at each scale are presented in the Habitat Appendix, but who decides the common prioritization criteria needs to be determined.

The same interdisciplinary team that advises the agencies on survey protocols and sequence should provide an implementation plan in which to test promising approaches to mainstem habitat improvements while maximizing opportunities to learn. Actions would proceed in accordance with a systematic, experimental management framework.

Additional Implementation Issues

In addition to the key issues described for the three implementation components, there are additional pervasive issues that must be addressed for habitat implementation to succeed. The Habitat Appendix address the following issues in more detail:

- **Tributary Water Quantity.** Instream flows and water diversions are areas in which states assert primacy. How would states propose to establish and enforce instream flows to satisfy **flow requirements** for fish? How could federal agencies establish policies, standards, criteria and/or methodologies to guide or support states in establishing and protecting adequate flows? Can federal and state governments establish incentive structures that will help comply with or avoid the need for regulation by rebuilding flows? What **infrastructure** limitations and **institutional barriers** will secure adequate instream flows?
- **Tributary Water Quality:** Idaho, Oregon and Washington are all under court ordered deadlines to complete TMDLS. Can TMDLs be completed and implemented in a manner that also meets recovery objectives for listed aquatic species? What is the appropriate role for federal agencies in water quality programs?
- **Agricultural lands.** Agriculture and rangeland use typically is not subjected to the regulations and ordinances associated with other land uses. Yet, literature and many federal and state conservation programs clearly confirm that agricultural land use patterns need to be changed for aquatic habitats to be adequately protected and restored. What steps can the federal government take to encourage and support sustainable agriculture that is complementary to habitat recovery objectives? How can agricultural land users be encouraged to improve soil and water conservation in a manner that protects and restores aquatic habitat?
- **The need for a habitat policy forum.** Entities working on hydropower issues have a variety of means to discuss and resolve implementation issues. Should there be a similar mechanism for habitat implementation? If so, under whose auspices and how should it be structured?
- **Coordinated funding**. At each planning scale, a funding strategy should be part of the plan. At the basin scale, the federal and state agencies need to coordinate on program priorities and funding criteria. At more local scales, funding strategies that identify and secure funds to implement

actions should be part of subbasin and watershed plans. Should federal land management agencies develop a process to ensure that land management agency funding is coordinated with other funding entities?

3.1.9 Performance Measures

Designing performance measures for habitat is a complex task because to be meaningful, population and habitat goals and objectives must address multiple scales: Basin, ESU, subbasin, watershed, subwatershed and reach. Ecological and managerial performance measures will be described at these spatial scales.

At the Columbia River Basin scale, performance measures will be general and mainly related to implementation of habitat goals and objectives outlined in this paper and to immediate actions. At the watershed scale, they will be more specific. These numerical measurements will be meaningful to listed fish when tied to specific populations and habitats to secure and restore. Reach scales are very specific and are dictated by the sensitivity of a site to a planned activity (e.g., riparian conditions sufficient to protect water temperature, **bank integrity**,

Table 2 - Sample Ecological and Managerial Performance Measures/Standards

Level	Ecological Criteria	Managerial Criteria
Basin	• Show an improving trend (>10% per decade) in the number of watersheds with high quality aquatic habitat as measured by an appropriate metric by 2005, continue to shift watersheds toward improved condition until a distribution consistent with VSP and H-VSP analyses is achieved. • Decrease the CWA, 303d water quality limited stream segments within each State within the Columbia Basin. The rate of decrease should be consistent with the States schedules for TMDL implementation. • Proportion of subbasins/watersheds where progress is being made against habitat performance measures.	• Assess implementation of immediate actions • Recovery plans for all ESUs listed as endangered fully developed by 2002. • Recovery plans for all ESUs listed as threatened fully developed by 2005. • Meet state schedules for the implementation of TMDLs to address CWA, 303(d)-listed streams.
ESU (sub-basins)	• Identification of the populations within the ESU that must achieve VSP level for recovery. • Identification of habitat conditions within the watersheds identified as critical to support population levels at VSP.	Number of subbasin assessments and plans completed.
Water-sheds (popula-tions)	• Sufficient subwatersheds with high-quality habitat conditions to maintain VSP population target.	Number of watershed assessments and plans completed.
Subwater-sheds	Distribution of reach-level habitat conditions across the subwatershed appropriate to maintain high levels of salmon production.	Assess use of mitigation measures described during **watershed analysis** in planning projects within the subwatershed.
Reach	Reach level standards needed to maintain subwatershed conditions in **properly functioning conditions** (PFC) (e.g., water delivery to channels, sediment generation, delivery of wood and other organic matter).	Assess implementation of mitigation measures that were described for the project.

woody debris input, etc.). Basinwide performance measures and approaches for defining finer scale performance measures are in the Habitat Appendix. Table 2 summarizes the ecological and managerial performance measures described more thoroughly in the Habitat Appendix.

3.1.10 Research, Monitoring and Evaluation

Regardless of the habitat strategies adopted, a coordinated research and monitoring program will be essential to assess the impact of management actions. Such an integrated program has the potential to begin to resolve several important issues, including:

- Quantifying the relationship between specific habitat alterations and salmonid productivity.
- Determining the life stages at which habitat impacts are realized.
- Determining the time lag between habitat alterations and changes in fish productivity.
- Assessing the appropriate scale at which habitat impacts should be managed.

Ideally, habitat restoration efforts and other alterations should be designed as replicated experiments. Coordination of habitat actions and analysis will allow researchers to determine not only the efficacy of a single action, but also the relative effectiveness of a variety of different actions. Such coordination will also provide researchers the means to assess the scale at which impacts are felt.

Monitoring programs aimed at assessing the impact of habitat alterations will include several components. First, management actions directed at habitat have the potential to yield a response in physical or biotic characteristics of the landscape as well as in fish productivity. Therefore, monitoring programs should include measures of fish productivity and project-specific habitat parameters (water temperature and riparian zone quality, for example). Next, improvements to habitat have the potential to influence survival at a variety of life stages (improved freshwater rearing habitat has the potential to increase the quality of smolts and therefore estuarine survivorship, for instance). It will be important to measure productivity at different life stages (juvenile, smolt, and returning adult) to identify the variety of impacts habitat actions might have.

3.1.11 Key Uncertainties

Any options for improving habitat in the basin must face these key uncertainties:

- What is the relationship between habitat quality and fish production potential?
- What kinds of restoration actions lead to long-term recovery of the aquatic environment?
- What level of coordination is desirable and achievable?
- What level of enforcement are state and local governments willing and able to achieve?
- How can funding sources maximize benefits through cost sharing?
- What is the best institutional structure for coordination?

3.2 Harvest

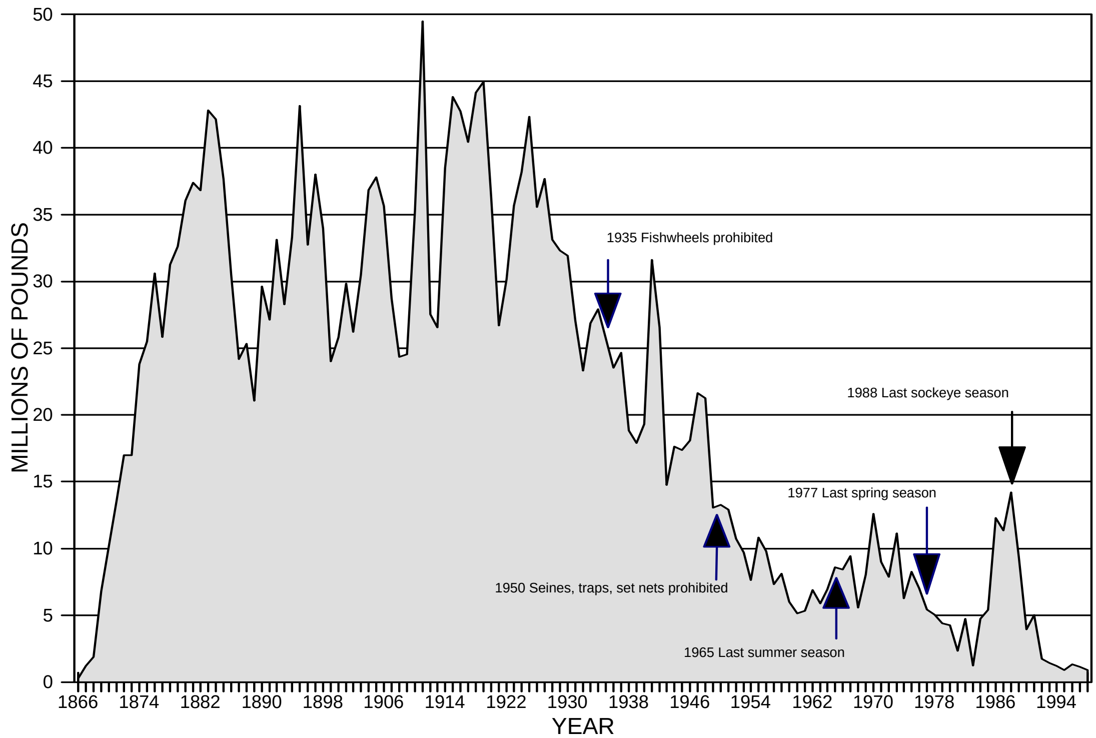
3.2.1 Overview

The history of harvest of Columbia Basin salmon parallels that of the entire region. For generations, salmon fishing was a central feature of Northwest tribal culture, religion and commerce. Indians from many tribes participated in seasonal fisheries all along the rivers and their tributaries. Tribal harvest of salmon from the Columbia Basin prior to European contact was about 4.5 to 5.6 million fish annually, but this estimate may be conservative (NPPC 1986). Many tribal customs evolved that ensured that harvests stayed in balance with the productive capacity of the resource.

With the arrival of European settlers and the advent of canning technologies in the late 1800s, commercial fishing developed rapidly. Figure 2 displays an estimate of the commercial landings of salmon and steelhead from the Columbia River from 1866 to 1997 (ODFW, WDF 1998). Since 1938, total salmon and steelhead commercial freshwater landings have ranged from a high of 2,112,500 fish in 1941 to

The Harvest Section does not address listed resident fish.

Figure 2 - Commercial Landings of Salmon and Steelhead from the Columbia River in Pounds



Source: ODFW, WDFW, 1998.

a low of 68,000 fish in 1995 (ODFW, WDF 1998). While freshwater fisheries in the basin were declining during the first half of this century, ocean fisheries were growing, particularly after World War II. This trend occurred up and down the West Coast, as fisheries with new gear types "leap-frogged" over the others to gain first access to the migrating salmon runs. Large mixed stock fisheries in the ocean gradually supplanted the in-river fisheries, which were increasingly restricted or eliminated to protect spawning **escapements**.

Salmon species vary widely in their ocean migratory patterns and life history characteristics and how harvest affects them. The extent to which changes in harvest can contribute to recovery varies widely across species, areas, and fisheries. For example, some ESUs, such as Snake River fall chinook, are harvested in ocean fisheries as far north as Alaska, and as far south as California. Current information, largely based on tagging hatchery fish, indicates that other ESUs, such as spring chinook, steelhead, chum, and Columbia River sockeye are harvested very little, if at all, in any ocean fisheries. All species are subject to harvest within the Columbia River and its tributaries, but the rate of harvest on each ESU varies. The Harvest Appendix provides statistics on run sizes, harvest and escapement trends for several salmon species and stocks.

Species harvested in the ocean are particularly difficult to manage. They migrate through multiple jurisdictions where they mix with fish populations from many geographic areas. Federal, state, and tribal entities manage harvest while the fish are present in their respective jurisdictions. Because many Columbia Basin stocks migrate through Canadian waters, over which the U.S. has no direct control, international cooperation is critical. The U.S. has sought to reduce the impacts of Canadian harvest through the Pacific Salmon Treaty. Details of the PST agreement are provided in the Harvest Appendix.

3.2.2 Contributions to Decline

The capacity of salmon and steelhead to produce more adults than needed for spawning affords the potential for sustainable harvest. This potential can be realized only if two basic management requirements are met: (1) enough adults are allowed to escape to spawn and perpetuate the run; and (2) the productive capacity of the habitat (including mainstem) is maintained. Catches would fluctuate naturally, due to such variables as ocean productivity cycles, periods of drought, and natural disturbance events, but as long as the two management requirements are met, the fisheries could be sustained indefinitely.

Unfortunately, both prerequisites for sustainable harvest have been routinely violated in the past. The lack of coordinated management across jurisdictions, coupled with competitive economic pressures to increase catches, or sustain them in periods of lower production, resulted in harvests that were too high, limiting the numbers of adults escaping to spawn. At the same time, habitat has been increasingly degraded, reducing the capacity of the salmon stocks to produce numbers in excess of their spawning requirements.

For many years, construction of hatcheries to produce more fish was the response to lost habitat productivity and declining catches primarily related to the construction and operation of the FCRPS. Because hatcheries require fewer adults to sustain their production, harvest rates in the fisheries were allowed to remain high, or go even higher, further exacerbating the effects of overfishing on the natural runs caught in the same fisheries.

Although the heyday of fishing has passed, with many historic fisheries now closed or tightly regulated, fishing pressure continues to be a factor in the decline of particular fish runs, such as Snake River fall chinook.

3.2.3 Current Management

There are two broad geographic areas of fishing relevant to Columbia Basin stocks – ocean fisheries and in-river fisheries. Ocean fisheries occur in coastal waters of Southeast Alaska, Canada, Washington, Oregon and California. U.S. ocean fisheries are governed by the PST, and by U.S. regulation. Canadian fisheries are governed by the PST and Canadian regulations. Fall chinook, including listed Snake River fall chinook, are harvested in significant numbers in these ocean fisheries. The Harvest Appendix describes the various federal, state and tribal jurisdictions that have regulatory authority over salmon fisheries.

Ocean fishing seasons are established annually by the regulatory jurisdictions. Information regarding fish abundance, escapement trends, and catch allocation among fisheries is compiled by fishery agency and tribal technical support committees. The information is then used in establishing annual fishing seasons in conformance with the Pacific Salmon Treaty, Indian treaty rights, and conservation needs. The Harvest Appendix provides an example of management objectives and considerations for Columbia River Basin natural and hatchery salmon stocks that are of significance to ocean salmon fisheries (PFMC 1999). Considerations include spawning escapement goals, management targets such as dam counts, and fishery allocation requirements. Performance in achieving management goals is annually assessed by the involved Canadian, federal, state and tribal management entities.

Freshwater fisheries (in-river fisheries) within the Columbia River basin are geographically divided. The commercial fishing area is located in the mainstem Columbia River from the estuary to McNary Dam. As runs permit, the non-treaty commercial fishery is conducted below Bonneville Dam, while the treaty Indian ceremonial, subsistence and commercial fishery is conducted in the mainstem reservoirs between Bonneville Dam and McNary Dam. The other mainstem areas and tributaries of the basin are managed for non-Indian recreational and treaty Indian ceremonial and subsistence fishing (as run sizes permit). The individual tribes hold rights reserved by treaty, and by other right, to fish specific areas of the mainstem and tributaries within the basin.

The freshwater fisheries presently occur primarily in the spring and in the fall. Salmon species and runs overlap in their time of return to the river and, therefore, the spring fisheries take a mixture of lower, mid- and upper Columbia River spring chinook, Snake River spring/summer chinook, sockeye and some steelhead. The fall fisheries harvest lower, mid- and upper Columbia River steelhead, Snake River steelhead, various lower, mid- and upper Columbia River fall chinook, and Snake River fall chinook salmon. The Harvest Appendix provides information and statistics on run timing, trends, salmon harvest and fish counts over mainstem dams.

Many fisheries have been reduced dramatically in recent years as a result of declining runs and subsequent harvest reforms. The trend of these reforms has been to reduce harvest rates in mixed stock areas in favor of harvests in areas closer to the rivers of origin (**terminal areas**). This trend is the result of two major factors:

- federal court rulings requiring that harvestable fish be available to tribal fishing areas, which generally are located in or close to terminal areas; and
- a growing recognition among fishery managers, reflected in modern management plans, that harvest rates in mixed stock fisheries must meet the conservation needs of natural stocks.

Large mixed stock fisheries once managed to maximize catch are now managed to reflect the productive capability and conservation needs of naturally-spawning fish present in those fisheries, and to achieve allocation objectives to terminal fisheries. The reduction of the ocean commercial salmon fishing fleet in Oregon and Washington is illustrative – the fishery has gone from over 7,000 vessels in the early 1980s to approximately 1,600 vessels in the late 1990s (PFMC 1999b).

Total harvest in recent years has declined due to both reduced harvest *rates* and decreases in total *numbers* of fish. The combined effect on fisheries has been dramatic, as evidenced by the precipitous declines in catches in nearly every mixed stock salmon fishery in Washington, Oregon and southern British Columbia. Nowhere is this more evident than in Columbia River fisheries, particularly Indian fisheries in the upper river. Indian rights to fish pursuant to federal treaties, Executive Orders, and the federal trust obligation have been seriously constrained to conserve depleted fish runs.

As a result of declining abundance, harvest reforms and ESA listings, ocean fishery harvest rates on Snake River fall chinook have been reduced by more than one third from the early 1990s (PFMC 1999c).

In-river fisheries have also been sharply constrained, in some cases for close to 30 years. Since 1973, there have been no Indian commercial fisheries for summer chinook, and none for spring chinook since 1977. Tribal ceremonial and subsistence fisheries have averaged less than 6 percent and 3 percent of the runs, respectively, over the last 5 years. Non-Indian fisheries in the lower river have likewise been constrained to very low levels, with less than a 1 percent harvest rate of upper river spring and summer chinook. The Snake River fall chinook harvest rates have been reduced by 30 percent from the 1988-93 base period to protect Snake River fall chinook. In 1998 and 1999, the fall season fisheries were further restricted to protect newly-listed upper Columbia and Snake River steelhead. In 1999, the harvest rate for wild Snake River fall chinook was about 31 percent, compared with a rate of about 45 percent from 1988 to 1993. The 1999 tribal harvest rate for **B-run** wild Snake River steelhead was less than 15 percent, compared to the former Columbia River Fish Management Plan (CRFMP) guideline of 32 percent for this stock. (1999 numbers are preliminary, unpublished data: *U.S. v. Oregon* Technical Advisory Committee.)

The *U.S. v. Oregon* case, originally filed in 1968 by the United States on behalf of four treaty Indian Tribes, defines harvest sharing principles for Columbia River salmon fisheries. There have been two management plans adopted by the Court since the original case was litigated. The most recent Columbia River Fish Management Plan expired in 1998 (CRFMP 1988). The CRFMP plan contained fish production, conservation and harvest goals intended to rebuild weak runs to full productivity while fairly sharing the harvest of upriver runs between treaty Indian and non-Indian fisheries in the ocean and Columbia River Basin. For a variety of reasons, the runs have not been restored as originally envisioned.

In response to ESA listings, the CRFMP was amended by agreement of the parties in 1996. These amendments imposed even greater restrictions on harvests. The restrictions that had already eliminated tribal spring and summer chinook commercial fisheries years earlier were continued, and the tribal ceremonial and subsistence fisheries were constrained to “conservation levels,” meaning harvest rates below 5-7 percent, for another three years. The fall season commercial fishery was constrained to limit impacts on the listed Snake River fall chinook, which arrive intermingled with the healthier upriver fall chinook runs (Hanford reach chinook and hatchery chinook).

Now, both the 1988 plan and the 1996 amendments have expired. For over two years, the *U.S. v. Oregon* parties have been engaged in difficult negotiations to develop a new plan, largely without success. Those negotiations are severely hampered by the uncertainty associated with many decisions framed throughout this paper. Meanwhile, beginning in 1998, the steelhead fisheries have been managed for increasingly lower harvests — and only after very contentious negotiations — triggered by the most recent ESA listings in August 1997 and March 1999. Because a substantial portion of the newly-listed upriver steelhead ESUs also arrive intermingled with fall chinook, another layer of constraint has been imposed on the tribes’ fall season mainstem fishery. These ESA constraints threaten the economic viability of the tribes’ last remaining commercial fishery in the basin.

3.2.4 Harvest Program Objectives

There are two program objectives for harvest.

1. To manage fisheries in a manner that prevents overharvest and contributes to recovery;
2. To provide fishing opportunities in a manner that comports with trust obligations to the tribes and complies with sustainable fisheries objectives to all citizens.

As noted above, the reduced catches in many fisheries, particularly mixed stock fisheries (including the Columbia River mainstem), are the result of both **harvest management** reforms and declines in total abundance. In the future, fishing in mixed stock areas will continue to be constrained by natural stocks present in the fishery and harvest allocation requirements. Management techniques such as time, area, and gear management will be used to ensure greater **harvest selectivity**. New mass marking technologies that make it possible to identify and selectively harvest hatchery fish, even in mixed stock areas, will continue to be developed and employed.

Weak stock management reforms are permanent. *Future increases in mixed stock area fisheries will depend almost entirely on increased production of weak natural populations and/or greater harvest selectivity***.** Future harvest depends on these improvements, whether stocks increase in the future due to fortuitous changes in environmental conditions, or due to natural populations being restored to healthy production because of reforms in the other Hs.

3.2.5 Harvest Strategies

The following strategies will help assure that the dual objectives of species conservation and harvest allocation are met. The strategies apply to ocean and freshwater fisheries.

Review, update, and/or establish biologically-based spawning escapement objectives.

These objectives reflect current and expected habitat **carrying capacity** and productivity and may be expressed as numbers of spawners, target harvest **exploitation rates**, or both.

Manage all fisheries to ensure all biologically-based objectives are achieved.

Continue to develop, refine, and apply selective fishery techniques. These include but are not limited to **mark-selective** fisheries, and known-stock fisheries. Techniques should avoid deleterious effects on populations, such as changing the size, age structure and run timing of exploited stocks.

Continue to develop and refine coordinated fishery harvest and production plans, especially as it relates to a successor plan to the now-expired CRFMP.

Replace lost tribal fishing opportunities on an expedited basis. Examples of this approach include development of subbasin fisheries in tributaries such as the Walla Walla, Clearwater, Umatilla, Klickitat, Deschutes, and other areas consistent with recovery objectives and tribal fisheries' needs. Other opportunities in the tributaries could also be identified, consistent with recovery and harvest objectives, to offset restrictions that have and will continue to constrain mainstem fisheries. The need to restore tribal fisheries to viable levels that comport with treaty and trust obligations will remain a high priority. However, there are relatively few opportunities where this strategy will produce results in the near term.

3.2.6 Harvest Options

Three basic options for harvest management were developed for consideration in concert with the other Hs. The following options presume that the harvest reforms of recent years will continue. These reforms, coupled with the dramatic decline in productivity, already have come at great cost to the fishery sector in the Pacific Northwest, especially for the tribes.

The recent expiration of the CRFMP and ongoing but unfinished negotiations for a new plan make it difficult to accurately identify any one particular option as representing the "status quo." Instead, we have included Option 2, which reflects 1999 harvest management. It incorporates changes flowing from the recent Pacific Salmon Treaty agreement and harvest rates applied in 1999 to the various fisheries subject to the now-expired CRFMP. From that option, we postulate two additional options, one that schedules more harvest in future years (Option 1), and one that contemplates further reductions in ocean and in-river fisheries (Option 3).

Option 1
Fishery Benefits During Recovery

This option implements the recently negotiated Pacific Salmon Treaty (PST) conditions in all ocean fisheries and, as contemplated in that agreement, further constrains U.S. fisheries south of Canada in some years if necessary to comply with the ESA. It would apply the constraints currently being developed for listed upper Willamette and lower Columbia chinook.

When abundance of listed stocks is similar to 1999, the in-river fisheries would be managed to limit impacts on listed chinook to conservation levels, e.g., 7 percent or less on spring chinook, and 5 percent or less on summer chinook. All in-river fall fisheries would be managed so as not to exceed the 1999 harvest rate limits for Snake River fall chinook (preliminary estimate is 31 percent) and B- run steelhead (preliminary estimate less than 15 percent). In anticipation of higher abundance in the future, a schedule would be developed that allows harvest rates to increase as abundance increases.

Option 2
Fixed In-River Harvest Rates (1999 levels)

This option is the same as Option 1, except that no stepped in-river harvest rate schedule would be included. In-river fisheries would be managed to limit impacts on listed spring and summer chinook to 7 and 5 percent, respectively, or less, and the fall season fisheries would be managed so as not to exceed the 1999 harvest rate limits for Snake River fall chinook and B-run steelhead. All of these rates would be frozen until recovery goals are achieved.

Option 3
Conservation Fishery Levels

This option implements the recently negotiated Pacific Salmon Treaty (PST) conditions for Alaskan and Canadian fisheries, except that additional voluntary reductions would be sought in these fisheries. It differs from Option 2 in that all other harvest impacts on listed populations would be reduced to conservation crisis levels for a period of years, after which it would shift to Option 1 or 2. Conservation crisis levels are defined as levels similar to the 1999 harvest rates for listed spring/summer chinook (5 to 7 percent), and comparable conservation crisis levels for listed Snake River fall chinook and steelhead.

3.2.7 Evaluation of Options

Biological Evaluation

Reductions in harvest will produce an immediate and quantifiable benefit to salmonid populations by increasing the number of spawning adults. For those ESUs currently subjected to low harvest rates, further reductions are unlikely to produce substantial benefits.

Snake River Spring/Summer Chinook

Snake River spring/summer chinook are currently harvested in-river at conservation levels (5-7 percent), and are not significantly taken in ocean fisheries. PATH sensitivity analyses indicate that under current operation of the hydropower system, the 1995 FCRPS Biological Opinion survival and recovery standards would be met or almost met if a 2-3 percent rate of harvest were maintained indefinitely as stocks rebuild (see Harvest Appendix). CRI analysis indicates that reductions in harvest rate or a moratorium on in-river harvest would increase the population growth rate by only about 1 percent. This increase alone will not substantially reduce extinction risk for this ESU.

Snake River Fall Chinook

Fall chinook in the Snake River Basin are subject to substantial harvest, both in the ocean and the river. PATH analyzed the effect of continuing current harvest schedules, reducing ocean harvest alone, and reducing ocean harvest (15 percent, 50 percent and 75 percent) and in-river harvest (50 percent) together (see Harvest Appendix). The probability of reaching survival and recovery goals increased with decreasing harvest. The 1995 Biological Opinion survival standards were met under all harvest scenarios. Recovery probabilities projected under lower Snake River drawdown scenarios exceeded the recovery criteria under each of the harvest scenarios, including the current harvest schedule. For those scenarios involving transportation, the ability to meet the recovery standard was sensitive to assumptions about indirect mortality (due to transportation) and passage models. The only scenarios with reduced harvest that did not meet recovery standards included increased reliance on transportation and assumptions of high indirect mortality. CRI analyses also indicate that harvest has a substantial impact on this ESU. Current analyses indicate that extinction risk in 100 years for this ESU can be reduced to less than 1 in 100 by reducing either in-river or ocean harvest by 75 percent (from 1993-1996 levels) or reducing both by 50 percent. However, harvest reductions may need to continue over the long term, raising serious implications for the exercise of tribal fishing rights and other harvest.

Since 60 percent of the ocean impacts occur in Canadian fisheries, a 50-75 percent reduction in ocean impacts would require the agreement of Canada. Although the recently negotiated Pacific Salmon Treaty will result in reductions in Canadian fisheries over those of the past decade, further reductions would be needed to achieve the 50-75 percent. Additional significant reductions in tribal harvest would require negotiations with the tribes.

Snake River Steelhead

Snake River steelhead face significant pressures from harvest in the river. CRI analyses suggest that reducing harvest rates to approximately 5-10 percent (the 1999 rate was less than 15 percent) will reduce the extinction risk for this ESU to less than 1 in 100 (in 100 years). However, harvest reductions may need to continue over the long term, raising serious implications for the exercise of tribal fishing rights and other harvest.

Other ESUs

The impact of harvest on other ESUs has not been quantitatively assessed. However, reducing harvest rates will reduce extinction risk for any ESU subject to substantial harvest, by increasing the number of spawners.

Other Considerations

Social and Economic Effects

The Northwest Power Planning Council's Multi-Species Framework Analysis has identified some possible costs associated with harvest strategies (see box). The Federal Caucus did not analyze the social and economic effects of the harvest options beyond what was identified in the Framework analysis.

Framework Analysis of Harvest Effects

Harvest strategies focus on the intentional take of species. Specific strategies might require selective fisheries, a focus on sport or commercial and sport fisheries, harvest based on escapement needs for the smallest population unit or population aggregates, management of overall harvest to meet escapement needs, or the use of various new harvest techniques, such as fish wheels or use of fish ladders to select individual fish for harvest or release.

Costs of harvest management include implementation costs, enforcement costs, and lost profits from reduced fishing. The Framework analysis estimated the economic value of the Columbia River Basin salmon and steelhead fishery to be nearly $25 million annually, given early 1990s conditions. Any strategy that reduces harvest would have the direct impact of reducing this annual value. Actual costs may be even higher, since economic incentives and value for fisherman may not be based solely on the value of the catch. In other words, the value to fishermen of a $25 million harvest might be more than $25 million. These additional costs are unquantified.

Reduction in harvest levels would require costs for implementation and enforcement, in addition to lost value. BPA has budgeted over $500,000 for such costs in its Year 2000 Fish and Wildlife Program.

In addition, BPA has budgeted nearly $5 million for strategies to control predatory fish, birds or mammals.

Conservation easements are more often used for habitat. They give the right to protect, improve, or maintain habitats or particular habitat conditions and are acquired through lease, purchase, or donation. A conservation easement on a fishery would similarly involve acquiring the right to reduce harvest.

Ecological Effects

The harvest options do not have broad ecological implications. The impact of the harvest options on resident fish and other aquatic species is not expected to be significant because few resident fish are harvested in in-river fisheries.

Effects on Tribal Rights

All of the harvest options have serious impacts on tribal fisheries. Even current levels of harvest are well below tribal harvest expectations. Severe limitations on tribal winter and spring season harvest for the past quarter-century have devastated this important cultural fishery for lower river tribes. . There is potentially a significant period of time before habitat and other improvements will take effect.

To meet tribal obligations in the short term, additional tributary and other selective harvest opportunities, particularly for tribes, should be explored. For some basins, hatcheries can help provide harvest opportunities in the interim (See Section 3.3, Hatcheries, for more details). However, it will continue to be a challenge to identify harvest locations and methods that are compatible with ESA efforts during this period. Few areas exist where hatchery and healthy stocks can be selectively harvested without affecting listed populations. **Selective fishing gear** is a promising tool, however satisfactory methods have not yet been developed for all fisheries.

3.2.8 Implementation Issues

There are several key institutional structures with responsibility to coordinate and implement harvest management decisions for ocean and freshwater fisheries. Authority to regulate fisheries is generally held by the various state, tribal, U.S. federal, and Canadian fisheries management agencies. The Harvest Appendix provides descriptions of these authorities and their roles in harvest management. The recent Pacific Salmon Treaty agreement attempts to coordinate U.S. and Canadian fisheries management and rebuild West Coast salmon stocks. However, the U.S. has no direct control over Canadian fisheries. *U.S. v. Oregon* remains the appropriate forum for addressing and implementing harvest and production actions relative to the rights of the treaty Indian tribes. It is essential that the parties to *U.S. v. Oregon* continue their negotiations. The parties are grappling with uncertainties relative to the ESA and management options under consideration in all four Hs. This paper is intended to provide the parties with additional context for those negotiations.

Well-coordinated harvest management is critical to ensuring that the sum of the impacts across all fisheries is consistent with recovery and sustainability of involved species. Implementation of any harvest management option will require a great deal of coordination among many players to be effective. Existing U.S. domestic public processes and the Pacific Salmon Commission are quite capable of carrying out measures necessary to implement Options 1 or 2. Option 3 will be more difficult, as it depends on implementation of restrictions in ocean fisheries, such as **conservation easements**, that go far beyond the recently negotiated Pacific Salmon Treaty agreements. If such restrictions were to be implemented voluntarily, they would have to involve coordinated and complementary actions by Canada.

3.2.9 Performance Measures

Performance measures for harvest primarily involve annual monitoring of stock status, catch and mortality by stock and fishery, and escapement enumeration and trends. In addition, court-mandated harvest allocation objectives will require monitoring. Measures will include:

- spawning escapement,
- harvest and exploitation rates,
- distribution of harvest over age, sex, and run timing,
- harvest **allocation percentages**, including tribal harvest allocations.

3.2.10 Research, Monitoring and Evaluation

There are several research, monitoring and evaluation actions that are essential to effective harvest management. They typically relate to Performance Measures, above. Additional key priorities are:

- Continue to refine stock assessment methods, including accounting for incidental fishery mortality in all fisheries, catch monitoring and reporting, escapement enumeration, and population identification;
- Continue to develop opportunities and methods of selective harvest, especially for tribal fisheries.
- Continue to enforce harvest regulations effectively.
- Develop value-added commercial enterprises to increase the net economic value of tribal fishing and fisheries.
- Account for the effects of various harvest methods, timing, gear, etc., on listed populations, for example, hooking mortality associated with selective ocean and in-river fisheries.
- Evaluate the change in growth rates and extinction risks in relation to implementing conservation fisheries.

3.2.11 Key Uncertainties

Any options for harvest in the basin must face these key uncertainties:

- Whether further reductions in Canadian and Alaskan harvests of fall chinook are possible.
- Whether there are opportunities to develop known-stock fisheries within the basin, particularly for the tribes, with acceptable impacts to listed species.

3.3 Hatcheries

3.3.1 Overview

Hatchery fish represent approximately 80 percent of the annual adult salmon and steelhead returning to the Columbia River Basin. Nearly all hatchery fish programs in the basin were intended to compensate for the loss of fish and fish habitat due to construction and operation of the FCRPS and nonfederal dams licensed by the Federal Energy Regulatory Commission. Major hatchery programs are authorized under federal legislation, such as the Mitchell Act (1938) and the Lower Snake River Compensation Program (1976). Other hatchery programs are operated as part of hydroelectric dam licensing agreements under FERC, and under the BPA Fish and Wildlife Program. Hatchery mitigation programs produce fish for harvest in the Columbia Basin and in ocean fisheries that extend from Alaska to northern California.

Hatcheries are not necessarily located in the area of habitat loss, nor do all species and fisheries benefit from hatchery programs. For example, most early mitigation for upper basin fish losses was fall chinook and coho hatcheries constructed under the Mitchell Act, with facilities located primarily in the area below The Dalles Dam. Increased Mitchell Act production has been focused above Bonneville Dam. There was also great uncertainty at the time whether anadromous fish would be able to survive in the upper basins once the FCRPS was fully developed. Tribal fisheries were especially hard-hit by these decisions because many fisheries are located farther upstream in the basin.

Modern hatchery production peaked in the early 1990s at over 200 million fish annually, declining to about 150 million at present. There are about 100 anadromous fish hatcher-

Figure 3 – Anadromous Fish Hatcheries Willamette River

Figure 4 – Anadromous Fish Hatcheries Lower Columbia River

Figure 5 – Anadromous Fish Hatcheries Middle Columbia River

Figure 6 – Anadromous Fish Hatcheries Upper Columbia River

Figure 7 – Anadromous Fish Hatcheries Snake River

ies and satellite facilities located in the Columbia Basin. The basin fish hatcheries are shown in the following figures.

The goal of most hatcheries has been to compensate/mitigate for fisheries by releasing fish directly from the hatchery facility. Upon reaching maturity, hatchery fish contribute to the various marine and freshwater fisheries, or return to the hatchery to spawn. The most commonly propagated salmonid species are chinook, steelhead and coho. Most hatchery programs were not designed with the intent of having hatchery-produced fish spawn in the wild.

Hatcheries are also used in resident fish programs including many intended as mitigation or substitution for losses associated with the FCRPS. Species commonly propagated include kokanee, rainbow and cutthroat trout. Some hatcheries produce listed and **sensitive species**. For example, the Kootenai River white sturgeon are being conserved through a preservation stocking program involving only wild **broodstock**. Bull trout and cutthroat trout facilities may have some role in reestablishing these species in former occupied ranges.

Beginning in the 1990s, there has been an increasing emphasis on preserving natural populations and several mitigation programs are currently being managed as conservation programs. The genetic legacy of some populations, or an entire ESU, is being maintained with **captive broodstock programs** that maintain fish in production facilities throughout their life cycle, such as the Redfish Lake sockeye program. Other populations are being maintained with a combination of release strategies including supplementation, the practice of augmenting naturally-spawning populations with juvenile or adult hatchery fish. Examples of natural populations of salmon augmented with hatchery-reared local stocks are Upper Columbia River summer steelhead, Upper Columbia spring chinook, Snake River fall chinook (Lyons Ferry Hatchery), Imnaha River chinook, South Fork Salmon River chinook, Tucannon River chinook, and Imnaha River steelhead.

Hatcheries have a long history of providing fish in an efficient manner for harvest and related social purposes. It is not clear whether hatcheries can be effectively used to help restore self-sustaining, naturally-spawning populations over the long term. A fundamental question is: how can artificial production be applied in a manner that not only avoids harm, but also assists in the conservation and rebuilding of wild runs? The issue is further complicated by the fact that access to freshwater habitat in the Columbia Basin has been blocked or habitat may be highly degraded, and hatchery production may be the only substitute for those fisheries losses. The parties to *U.S. v. Oregon* are negotiating an integrated harvest and production plan, as described in Section 3.2, Harvest. The challenge inherent in developing a new plan will be to meet the conservation needs for species listed under the ESA while meeting treaty and federal trust obligations and providing sustainable Indian and non-Indian fisheries. The treaty and trust obligation is described in additional detail in Section 1.5 of this document. The parties to *U.S. v. Oregon* hold a wide range of views about the use of artificial production to sustain and restore natural populations and fisheries and are continuing to work on resolving areas of disagreement. A draft document called "**Fed 1**" provides current federal agency views regarding production in the various subbasins (see the Hatcheries Appendix). The Nez Perce, Umatilla, Yakama, and Warm Springs tribes have also developed a detailed anadromous fish restoration plan that provides recommendations on the use of artificial production, especially supplementation, to assist salmonid restoration (CRITFC 1996).

Captive-broodstook program - A form of artificial propagation involving the collection of individuals (or gametes) from a natural population and the rearing of these individuals to maturity in captivity. For listed species, a captive broodstock is considered part of the evolutionarily significant unit (ESU) from which it is taken.

3.3.2 Contributions to Decline

Hatcheries play a unique role in the current crisis. They have been identified both as part of the solution and as one of the causes. Hatcheries can have negative impacts on wild populations through ecological and **genetic interactions** between hatchery and wild fish although the magnitude of impacts is uncertain and unquantifiable. However, they also provide fish for harvest and are being used as a last-resort method of preserving important genetic resources for fish that are at a high risk of extinction in the wild.

The report *Upstream*, sponsored by the National Research Council, provides a thorough summary of the effects of hatcheries (NRC 1996). The *Upstream* report and other recent scientific studies have identified a number of risks associated with hatchery production.

As adults, hatchery fish intermingle with wild fish in the ocean and when they return to the river. If harvest rates are based on the abundance of hatchery fish, weaker stocks of wild fish may be over-harvested. In recent years, harvest management has undergone major changes, and become much more responsive to weaker-stock components in mixed-stock fisheries (see Section 3.2, Harvest).

Artificial propagation has the potential to impact the fitness of wild salmon populations in several ways. First, many hatchery programs use broodstock that are not native to the area in which they are released. If these fish interbreed in substantial numbers with local wild fish, **outbreeding depression** or a loss of **local adaptations** could potentially reduce the fitness of the local natural population. Second, even if the hatchery population is derived from a local natural population, the fitness of the natural population could be potentially reduced over time by the domestication that occurs in the hatchery or by poor hatchery broodstock mating protocols that increase inbreeding or reduce **genetic variability**. Many of these effects are theoretical, though some have been empirically studied in specific cases. The likely severity of many of these effects can be difficult to predict in any particular case.

There are a number of ecological interactions that can take place between hatchery and wild fish. These interactions are widely considered harmful to wild fish, although the effects are not well quantified (NMFS 1995). These interactions include predation on wild fish by larger hatchery fish, competition for space and food, and disease transmission. There is great uncertainty about the number of fish that can be supported in freshwater streams, the estuary or the ocean. Release of large numbers of hatchery fish may reduce survival of wild fish by increasing competition for food or habitat in any of these habitats.

3.3.3 Current Management

A number of steps have already been taken to begin to address problems associated with interactions between hatchery and wild fish. For example, many hatchery programs no longer use **non-indigenous** stocks. By altering the time, location, or size, of released fish, competition and predation between hatchery and wild fish may be reduced. Rearing fish in more natural conditions may produce fish that are less domesticated and have more “wild-like” behaviors and appearance. Future research is needed to determine whether these actions result in better survival of hatchery fish in the wild and in fewer negative interactions with wild fish.

A number of independent scientific panels have critically reviewed hatcheries and have made recommendations to improve hatchery performance. Their reports include the Integrated Hatchery Operations Team, 1994; the Independent Scientific Group, 1996; the National Research Council, 1995; and the National Fish Hatchery Review Panel, 1994. These reports provide guidance for making hatchery programs more compatible with current conservation biology science.

The most recent effort, the Artificial Production Review (APR) by the NPPC (1999), to be submitted to Congress in 1999, builds upon these efforts. It provides an overview of hatcheries, recommendations for coordinating basinwide hatchery policies, recommendations for improving hatchery performance and an implementation plan. When completed, the APR may provide the best vehicle for implementing coordinated policies and actions. A detailed summary of the APR Report can be found in the Hatcheries Appendix. Further guidance can be found in additional publications such as NMFS’ recommended protocols for the use of captive broodstock (NMFS 1999a), and in the March 1999 Biological Opinion on Artificial Production (NMFS 1999b). Also see the Hatcheries Appendix for a description of management tools that are under development.

3.3.4 Hatcheries Program Objectives

There are four objectives for hatcheries:

1. Minimize the adverse effects of hatchery production on wild fish,

2. Conserve genetic resources,
3. Help restore natural populations, and
4. Use hatcheries creatively to mitigate for lost habitat or reduced productivity, providing a sustainable harvest resource for tribal and nontribal fisheries.

3.3.5 Hatcheries Strategies

The Draft Artificial Production Review (NPPC 1999) provides recommendations for policies to guide future operation of hatcheries, performance standards and recommendations for implementation. That effort is endorsed here and discussed below. A number of overall strategies or actions will be taken or considered regardless of the hatchery option selected. These are discussed below.

Use artificial propagation when predicted benefits outweigh risks.

Managers should conduct a detailed risk/benefit analysis on a subbasin-by-basin level before using artificial propagation. In those situations where the benefits of such a program outweigh the risk (e.g., risk of extinction is high without artificial propagation), appropriate artificial propagation techniques should be applied. Examples include captive broodstock and supplementation. Additional conservation actions will almost always be necessary to achieve recovery regardless of whether supplementation is performed, because supplementation does not address the underlying cause of a natural population's poor status.

Base hatchery programs on Hatchery Genetic Management Plans (HGMPs) for each hatchery program.

Hatchery and genetic management plans should be developed for each hatchery program. These HGMPs should address genetic issues, such as the use of local stocks or the effects of **artificial selection**. (Specific strategies and associated actions that could be implemented under an HGMP are detailed in the Hatcheries Appendix). The HGMP should also address the relationship between planned production and planned harvest. In addition, such plans should minimize the potential for adverse ecological effects of hatchery production on natural populations. Finally, all HGMPs should include a thorough monitoring and evaluation plan for evaluating risks and benefits of projects (see Hatcheries Appendix).

Apply well-designed adaptive management programs to resolve critical uncertainties.

Hatchery programs and strategies must be flexible and responsive to changes in the status of habitat, hydropower and fish productivity. The level of benefit that can be derived from artificial propagation programs, as well as the conditions under which those benefits are realized, is uncertain. Hatchery conservation and mitigation programs should be designed to address some of these uncertainties and should be part of an adaptive management program. This will entail designating some tributaries as “controls,” to be managed without hatchery releases as part of an experimental monitoring effort.

Implement sustainable fishery programs that enable harvest of salmon consistent with the objectives set forth in this document.

Production plans should continue to explore the use of artificial production to create known-stock harvest opportunities to mitigate for lost harvest opportunities for tribal and nontribal fisheries. Mitigation and compensation programs should transition to **indigenous** stocks where feasible and appropriate. The use of **non-endemic** stocks for terminal fisheries may continue where impacts to wild stocks (**straying**, outbreeding depression, predation, competition, etc.), can be minimized. These programs should be closely monitored and adaptive management applied as necessary to prevent adverse impacts to natural populations.

Non-endemic stocks are not native to a specific region where they are used.

3.3.6 Hatcheries Options

Three basic options were developed for hatchery production. Option 1 involves a continuation and expansion of hatchery reforms now underway, and modifications as recommended in the NMFS Biological Opinion on Hatchery Production. Option 2 is an expansion and acceleration of Option 1 actions in the event that the status of salmon populations fail to improve in the near term.

Under Option 3, hatchery production is shifted to hatchery programs that are part of an ESA **conservation strategy** or selective fishery strategy, and there are sharp reductions in mitigation hatcheries. *All of the options include numerous hatchery reforms already underway in the basin.*

Option 1
Currently Planned Programs

This option includes actions that have been recently implemented, planned actions required by Biological Opinions, and changes that may result from a new *U.S. v. Oregon* management plan. These actions are intended to conserve genetic resources of listed species and to improve hatchery mitigation programs in the basin. The details of these programs are included in the "Fed 1" proposal made by the federal parties in *U.S. v. Oregon* negotiations (see Hatcheries Appendix). Management strategies to implement the currently planned programs would continue to be made on a subbasin-by-subbasin basis for each species.

Hatchery Conservation Programs — This option is presently being implemented for populations at high risk of extinction such as those in the Snake and upper Columbia regions. Under the Fed 1 proposal, there would be approximately 20 listed and **at-risk populations** maintained in hatcheries until environmental conditions improve or improvements can be made in other Hs.

Hatchery Mitigation Programs — Mitigation hatcheries will continue to produce fish for harvest at roughly current levels. Practices at these hatcheries will be improved as programs continue to convert to local stocks, and when other actions identified in Section 3.3.5, Strategies, and in Fed 1 are implemented. In some cases improvements will result in decreases in hatchery production. Programs may also continue to experience reductions in fish production due to budget considerations and other priorities.

The main feature of this option is that it does not seek to change the currently planned programs for either conservation or mitigation. The rationale for continuing conservation programs at this level is to prevent some, but not all, local extinctions. The rationale for not increasing conservation programs is that **hatchery intervention** to conserve genetic resources is costly and difficult, conservation programs are unproven, and the risks of hatchery interventions to preserve local populations may outweigh the potential benefits to the population or the ESU. This option would not preclude subsequent increase in conservation programs if warranted.

The rationale for continuing current mitigation programs rather than seeking further reductions is that the harmful effects of hatchery production are uncertain and not well-quantified; improvements currently being implemented will reduce many of the risks hatcheries pose to wild populations; and mitigation programs provide an important benefit to tribal and nontribal fisheries.

Option 2
Increased Conservation Programs

This option would increase the number of conservation hatchery programs beyond the currently planned levels, and continue currently planned improvements and other changes in existing mitigation programs.

Hatchery Conservation Programs — Additional programs beyond those identified in Option 1 would be initiated where the combined actions in the three other Hs are insufficient to halt the decline in productivity and survival of listed or at-risk populations. Actions identified in Option 1 would be accelerated and expanded. Hatchery programs would be expanded for populations at risk of extinction from the present level of about 20 populations, to perhaps as many as 70 populations.

Decisions about which additional populations to conserve would be based on a risk assessment conducted on a subbasin-by-subbasin basis. The Hatcheries Appendix describes how such risk assessments would be conducted.

Hatchery Mitigation Programs — Same as Option 1.

The main feature of Option 2 is an expansion of hatchery conservation actions. The rationale is to conserve populations considered to be at significant risk of extinction. The assumption is that where populations are at significant risk of extinction, the potential benefits of hatchery intervention outweigh the risks of extinction. Another assumption is that the risk of local extinctions outweighs the costs of conservation.

Option 3

Increased Conservation Programs and Significantly Decreased Mitigation Programs

This option would increase the number of conservation hatchery programs, as described in Option 2, while significantly decreasing mitigation programs below currently planned levels.

Hatchery Conservation Programs — Same as Option 2.

Hatchery Mitigation Programs — Mitigation programs would be significantly reduced under this option. Reductions would be decided on a case-by-case basis using criteria such as genetic and ecological effects, the risk that the mitigation program poses to **natural fish**, and harvestability in selective fisheries. Under this option, hatchery smolt production might be reduced as much as 50-80 percent.

The main feature of Option 3 is that it incorporates the expanded hatchery conservation aspects of Option 2 while requiring a significant reduction in mitigation programs. The rationale for increasing conservation programs is the same as for Option 2. The rationale for decreasing mitigation programs is that, although the harmful effects of hatchery production are uncertain and not well-quantified, all major scientific reviews of hatchery practices warn of the biological risks associated with hatchery programs.

3.3.7 Evaluation of Options

Biological Evaluation

Biological evaluation of hatchery options is complicated not only because hatcheries may have both negative and positive effects, but also because hatchery production has increased as natural productivity has decreased. In the absence of experiments explicitly addressing hatchery effects, it is difficult to determine the role hatchery practices have played in reducing or maintaining natural productivity.

CRI Program. The Cumulative Risk Initiative program being conducted by the Science Center includes an assessment of the impact of hatchery fish on wild stocks. CRI is identifying correlations between spawning escapement and hatchery releases, using the PATH index stocks for the Columbia River Basin, to determine the impact of releases of different salmonid species at different life stages (e.g., egg, fry, smolt) on natural productivity. Future CRI modeling efforts will explore the risks and benefits of supplementation from both a genetic and population dynamic perspective.

PATH. In its retrospective analysis, the PATH group detected no correlation between productivity of spring/summer chinook from streams with and without chinook hatchery production. Additional analysis will determine if there is a correlation between hatchery steelhead releases and spring/summer chinook productivity.

Natural fish are fish produced by parents spawning in a stream or lake bed, as opposed to a controlled environment such as a hatchery.

Ecosystem Diagnosis and Treatment (EDT) Assessment. The EDT project is examining the potential impact of each Framework alternative on various basin salmon populations using an “expert system” approach. To what extent that effort will yield additional quantitative information on the options presented here is unknown.

Other Considerations

Social and Economic Effects

Reduction in production of fish in mitigation hatcheries may reduce the fish available for harvest and would affect programs intended to mitigate for lost fisheries resulting from construction of the FCRPS. Reductions could also affect commitments to provide fish under the U.S.-Canada Pacific Salmon Treaty. Selective sport fisheries that target marked fish from mitigation hatcheries are likely to be affected by all of the options. Part of the qualitative deliberations may include redirecting hatchery mitigation funds to other activities. For example, current hatchery mitigation funds may be better spent on activities such as conservation hatchery production, if it is decided that such actions produce grater benefits, with fewer risks to wild salmonids.

Hatchery conservation programs are costly, as are improvements to mitigation hatchery programs. Investment in hatcheries has long-term implications. If salmon populations improve substantially, then the need for long-term propagation programs and associated costs decline. If, however, salmonid survival increases only modestly, or continues to decline, then hatchery intervention becomes essential to prevent further extinctions. The Hatcheries Appendix provides information on potential costs for hatcheries under the three options described. Even Option 1 of the hatchery options represents an increase in costs over the recent past. The Framework Analysis gives the current sources of information about hatchery production and operation costs (see box).

Ecological Effects

It is difficult to predict the ecological effects that might result from implementing the different hatchery options. A reduction in hatchery production could reduce the number of salmon and steelhead carcasses that provide nutrients in basin tributaries. Reductions in hatchery production could also affect populations of predator species, such as black bear, river otter, sea lions, Caspian terns, northern pikeminnow, bald eagle and other fish-eating birds.

Framework Analysis of Hatchery Effects

Little cost information is available for strategies that would reduce, eliminate or expand hatchery production. Costs arise in at least two different ways—the actual costs for funding hatcheries, which may increase or decrease as production expands or contracts, and the economic value produced by hatchery fish.

The most important sources of information about hatchery production and operation costs are from current programs funded by BPA, the states, and other sources. BPA's projected budget for hatchery production and operation programs for the year 2000 is nearly $70 million. The Framework process estimated that the average cost for most hatcheries in the basin is between $1.50 and $6.00 per pound of fish produced.

The Framework process also estimated that the economic cost of eliminating hatchery programs could be up to $140 million per year.

Effect on Tribal Rights

Reductions in hatchery production will significantly reduce fish available for harvest in tribal fisheries. The lower river tribes view hatchery production as an essential strategy for maintaining important cultural and economic values.

3.3.8 Implementation Issues

Hatcheries will continue to be needed to achieve species recovery under the ESA and to meet purposes such as sustainable fisheries and tribal fishing rights. To satisfy these needs and to have a more effective hatchery program, an integrated federal effort is needed. Hatcheries currently represent a large component of Columbia River Basin expenditures, and there are significant funding implications related to the options under consideration. As a priority, the various federal funding mechanisms and authorities involved, such as BPA, Lower Snake River Compensation Program, Mitchell Act, FERC and other federal programs, should develop a greater degree of coordination to maximize the potential benefits of various hatchery programs.

A key implementation goal is to use the federal funding mechanism to improve budget planning for hatcheries, to help set budget priorities (such as funding and construction schedules for upgrading hatcheries to meet necessary hatchery reforms), and to improve the level of certainty associated with planning and funding hatcheries. Coordinated planning should produce a more responsive, methodical, and cost-effective approach to urgently needed programs for species recovery and for meeting fisheries needs.

3.3.9 Performance Measures

The NPPC's draft APR report (NPPC 1999) includes performance standards and indicators, and is a commendable effort to quantify both the benefits and risks of using hatcheries as management tools. The APR effort builds upon a large body of work that includes the products of the APR Science Review Team, the

Integrated Hatchery Operations Team (IHOT) and the Pacific Northwest Fish Health Protection Committee. The main criterion identified for hatchery success is to achieve the identified benefits while managing risks through a research, monitoring and evaluation program. The performance standards relative to benefits and risks are displayed in the following tables. The APR represents a significant interagency, tribal and public effort that is designed to set up accountable, performance-based management of hatchery programs and should help streamline implementation of NMFS' Hatchery Biological Opinion(s) and other artificial propagation improvements. A more extensive summary of the APR report is provided in the Hatcheries Appendix.

3.3.10 Research, Monitoring and Evaluation

Steps being taken now should improve hatchery fish survival while reducing harm to wild populations. Because the impacts of supplementation on wild populations are not fully understood, hatchery options must be

Table 3 - Performance Standards Related to Hatchery Benefits

	Augmentation[a]	Mitigation[b]	Restoration[c]	Preservation/ Conservation[d]	Research[e]
1. Provide predictable, stable and increased opportunity for harvest.	•	•			
2. Achieve genetic and life history conservation.			•	•	
3. Enhance local, tribal, state, regional, and national economies.	•	•	•	•	
4. Fulfill legal/policy obligations.	•	•	•	•	
5. Contribution of fish carcasses to ecosystem function by subbasin and by hatchery.		•	•		
6. Provide fish to satisfy legally mandated harvest.	•	•	•		
7. Will achieve within-hatchery performance standards.	•	•	•	•	
8. Restore and create viable naturally spawning populations.		•	•	•	
9. Plan and provide fish with coordinated mainstem passage and habitat research in the Columbia Basin.					•
10. Conduct within-hatchery research; improve performance or cost effectiveness of artificial production hatcheries to address the other four purposes.					•
11. Minimize management, administrative, and overhead costs.					•
12. Improve performance indicators to better measure performance standards.					•

Key:

a. Purpose is to increase harvestable numbers of fish.
b. Purpose is to replace or compensate lost habitat capacity of naturally producing fish with artificially produced fish (anadromous or resident, native and non-native) for harvest or some other reason.
c. Purpose is to hasten rebuilding or reintroduction of a population to harvestable levels.
d. Conserve genetic resources or fish populations impacted by habitat loss or degradation, including preservation of populations faced with imminent demise, using methods such as captive propagation and cryopreservation.
e. Determine how to effectively use artificial production to address the other hatchery purposes.

Source: NPPC 1999. Artificial Production Review.

thoroughly monitored and evaluated to ensure that management objectives are, in fact, being achieved. Experimental actions and monitoring at various life stages will improve knowledge and decisionmaking over the long term. In the interim, adaptive management will be a necessary ingredient. Monitoring results can then potentially determine if and where improvements are occurring at various life stages, whether criteria are being met and whether additional management actions are needed.

Monitoring and evaluation programs should collect information about artificial propagation projects necessary for evaluating the benefits and risks of the projects. Minimal information that should be collected for all artificial propagation projects includes:

- Spawning population size of natural populations in target area.
- Proportion of hatchery-produced spawners in natural populations in target area.
- Spawning population size in the hatchery.

Table 4 - Performance Standards Related to Hatchery Risks

	Augmentation[a]	Mitigation[b]	Restoration[c]	Preservation/ Conservation[d]	Research[e]
1. Harvest management plan to protect weak populations where mixed population fisheries exist.	•	•	•		
2. Do not exceed the carrying capacity of fluvial, lacustrine, estuarine, and ocean habitats.	•	•	•	•	•
3. Assess detrimental genetic impacts among hatchery vs. wild where interaction exists.	•	•	•	•	•
4. Unpredictable egg supply leading to poor programming of hatchery production.	•	•	•	•	
5. Production cost of program outweighs the benefit.	•	•	•	•	
6. Cost effectiveness of hatchery ranked lower than other actions in subregion or subbasin.	•	•	•	•	
7. Will not achieve within-hatchery performance standards.	•	•	•	•	
8. Evaluate habitat use and potential detrimental ecological interactions.	•	•	•	•	•
9. Avoid disease transfer from hatchery to wild fish and vice versa.	•	•	•	•	
10. Evaluate impact on life history traits of wild and hatchery fish, from harvest and spawning escapement.	•	•	•	•	
11. Assess survival of captive broodstock progeny vs. wild cohorts.				•	
12. Depleting existing population spawning in the wild through broodstock collection.			•	•	

Source: NPPC 1999. Artificial Production Review.

- Proportion of wild-produced spawning in the hatchery.
- Total number, size, life-history stage, and marking status of all fish released by the hatchery.
- Location and method of all releases.
- Mean life-time survival and fecundity of artificially and naturally propagated populations in target area.
- Age structure of naturally and artificially propagated fish in the target area.
- **Homing** or straying rates for artificially propagated fish.
- Information on the health of the artificially propagated fish (disease, condition, etc.).
- Information on all animal husbandry protocols used by the hatchery.

Examples of other information that should be collected for specific projects include:

- Fry and/or smolt production of natural populations in target area.
- Ecological interactions between program fish and natural fish (same as other species) in target area.
- Behavior, **morphology**, reproductive success, and/or physiology of naturally and artificially propagated fishes in the target area.
- **Geneflow** from program fish into natural populations.
- Genetic variability in the naturally and artificially propagated populations in the target area.

A summary of current BPA-funded supplementation and captive propagation research is provided in the Hatcheries Appendix.

3.3.11 Key Uncertainties

Some of the key uncertainties for hatcheries are:

- Under what circumstances can artificial propagation aid in achieving the ESA objective of self-sustaining, natural populations?
- Are habitat carrying capacity and the numbers of hatchery fish being released limiting wild fish recovery?
- Are natural populations projected to be self sustaining without intervention?
- Are habitat carrying capacity and the numbers of hatchery fish being released limiting wild fish recovery? To what degree do ecological interactions with hatchery-released fish affect the growth and survival of wild juveniles?
- What is the reproductive success of naturally spawning hatchery-origin fish? Has interbreeding between hatchery-origin fish and wild fish affected the average fitness of wild populations?
- What is the current distribution of genetic variation in hatchery and wild stocks?

3.4 Hydropower

3.4.1 Overview

Hydropower development has had profound effects on the basin's aquatic species. For salmon and steelhead, much of the impact occurred when the Grand Coulee and Chief Joseph dams in the Columbia River and the Hells Canyon Complex in the Snake River blocked passage to 55 percent of historic spawning areas. Many smaller dams on the tributaries have also blocked salmon spawning areas and harmed resident fish (see Map 7). The options examined do not include removal of these dams or reintroduction of salmon and steelhead above them. However, in the discussion on overall implementation of a unified restoration program, we do recommend that more detailed planning be carried out for each ESU. In that planning the need for fish passage facilities at – or removal of – blocking dams should be considered.

Morphology is the structure, form and appearance of an organism.

3.4.2 Contributions to Decline

Hydropower development in the basin has affected salmon and steelhead in many ways. The hydropower system affects all life stages of these fish, except for their ocean residence. For instance, the 28 storage reservoirs in the basin reduce flows and alter **flow timing**. By 1979, the total storage capacity in the basin, including Canada, had reached nearly 40 percent of the Columbia River's annual average discharge. Storage of water for winter hydropower generation and spring flood control has substantially altered the natural

Dewatering is the removal of all the water from an artificial or natural container or channel. It typically refers to the immediate downstream habitat effects associated with a water withdrawal action that diverts the entire flow of a stream or river to another location.

Passive integrated transponder (PIT) tags are used for identifying individual salmon for monitoring and research purposes. This miniaturized tag consists of an integrated microchip that is programmed to include specific fish information. The tag is inserted into the body cavity of the fish and decoded at selected monitoring sites.

runoff pattern by increasing fall and winter flows and decreasing spring and summer flows. Changes in the pattern of the runoff affect flows and temperature in the river channel as well as the character of the estuary and freshwater **plume**. The change in temperature affects the migration timing of adult and juvenile fall chinook, the survival of summer-migrating juveniles and adults in the river, and increases susceptibility to disease. Voluntary or involuntary spill can create high levels of dissolved nitrogen gas that can be lethal to fish.

The reservoirs behind the dams increase the total width and depth of the river, decreasing river velocity and turbidity. These conditions increase the travel time of juveniles and adults. Increased travel time exposes juveniles to predators and alters the timing of their ocean entry. The reservoirs have also substantially modified the temperature of the river and provide ideal habitat for salmon predators.

In addition to the effects of impoundment, the dams themselves block or delay upstream and downstream fish migration. Many juvenile fish are killed regardless of how they pass dams. Turbines kill the most juveniles, followed by bypass systems and spill. Juvenile fish may also suffer **indirect mortality** from injury or stress caused from dam passage. The delay in juvenile migration also has indirect effects, increasing the time it takes to reach the estuary, increasing exposure to predators and changing the timing of ocean entry. Adult fish may fall back through dams and die passing through turbines, or later from injury and migration delay.

Hydropower development in the basin has also affected resident fish and other aquatic species including the Kootenai River white sturgeon, bull trout, westslope cutthroat trout, and burbot. In 1994, the USFWS listed Kootenai River white sturgeon as endangered because few juveniles have survived to enter the population. Seasonal changes to the river, especially in spring and summer because of Libby Reservoir refill operations, is a major factor affecting the survival of Kootenai River white sturgeon in the Kootenai River and Kootenay Lake. Water management practices have also impacted bull trout. The major impacts associated with the FCRPS include: 1) passage barriers; 2) inundation of spawning and rearing habitat; 3) modification of the range of streamflows and water temperatures; 4) **dewatering** of the shallow water zone; 5) reduced productivity in reservoirs; and 6) **gas supersaturation**. Impacts of FCRPS construction and operation are further detailed in the Hydropower Appendix. Listed Snake River snails occur in the Snake River well above the FCRPS dams, but they may be affected by some of the hydropower options considered.

3.4.3 Current Management

Because extensive migration delays and turbine passage can harm or kill salmon and steelhead, the Corps has developed several methods for moving them past the dams and reservoirs. Mechanical bypass systems route juvenile fish away from turbines. Water is spilled at the dams to further reduce the number of fish that pass through turbines. At some dams, juvenile fish are collected and loaded into barges, which carry them around the remaining dams and release them at sites below Bonneville Dam.

A flow augmentation program, first called for by the NPPC and later increased under NMFS' 1995 and 1998 Biological Opinions, aims to restore more natural flow patterns during the time juvenile and adult salmon and steelhead are migrating. The 1995 and 1998 Biological Opinions include two flow management strategies: limit the winter and spring drafts of storage reservoirs to increase spring flows and the probability of full reservoirs at the beginning of summer; and draft from storage reservoirs during the summer to increase summer flows.

These measures have helped mitigate the effects of the hydropower system on migrating juvenile salmon. Other measures, detailed in the 1995 and 1998 Biological Opinions and in annual fish operating plans, further reduce juvenile and adult mortality through the hydropower corridor. These measures have succeeded in increasing salmon and steelhead survival, though the hydropower system continues to claim large numbers of juvenile and adult fish. The federal agencies have developed a sophisticated ability to measure direct mortality of fish passing through the system using **passive integrated transponder (PIT) tags**, radio tags, **hydroacoustics** and other methods. There remains, however, considerable uncertainty and controversy about the level of indirect mortality of both juvenile and adult fish passing through the system, which is difficult to measure and associate with causes. This is one of the key uncertainties the region faces in deciding whether it will try to recover Upper Columbia and Snake River salmon and steelhead without removing dams.

Special operations have also been implemented at FCRPS projects to benefit resident fish. Special flow operations for Kootenai River white sturgeon are typically in effect at Libby Dam from April through August. In 1999, temporary flow **ramping rates** and stable flows were established for Libby and Hungry Horse dams to protect bull trout. Other operations have been implemented at FCRPS projects to benefit non-listed resident fish species.

3.4.4 Hydropower Program Objectives

There are two objectives for hydropower:

1. to provide adequate survival and maintain healthy adult and juvenile anadromous fish inhabiting and/or migrating through the hydropower system;
2. to provide instream and reservoir environmental conditions necessary to provide adequate survival of resident fish and other aquatic species.

(Note that survival in these options refers to survival of individuals or cohorts, within the context of actions in the other Hs, rather than the survival and recovery of the ESU under the ESA).

3.4.5 Hydropower Strategies

Manage flows to facilitate downstream salmon migration and meet resident fish needs.

Provide a variety of passage routes for juvenile salmonids and lamprey at mainstem dams while protecting life-stage diversity. This includes spill, mechanical bypass, and potential surface bypass and fish-friendly turbines for juvenile passage. It also includes continued and improved passage through fish ladders for adult fish.

Provide conditions in the mainstem to provide adequate spawning habitat and a high rate of survival for juvenile and adult salmon and other at-risk species. This includes actions such as limiting flow fluctuations.

Implement physical measures and operational actions to optimize water quality conditions (temperature and dissolved gas) where consistent with overall objectives and other strategies.

3.4.6 Hydropower Options

Three basic options, or sets of measures and actions, were examined to achieve the objectives and tested for the sensitivity of different population dynamics of ESUs to them. Option 1 continues the current program, leaving the existing system in place and maintaining the fish passage facilities associated with it. Option 2 is an aggressive program that goes beyond the current level of investment to improve passage through the existing system. Option 3 removes the Snake River dams. We describe each option in terms of the strategies and actions it includes for the Columbia and Snake rivers, respectively, and for system configuration (i.e., physical alterations at dams) and operation (i.e., flow, spill, transportation, etc.), respectively. See the Hydropower Appendix for detailed descriptions.

The Federal Caucus did not examine the option of removing federal Columbia River dams. The Multi-Species Framework Project will evaluate alternatives in which John Day and McNary Dams are removed. They are not included here because they are not viable options for the federal agencies for a decision in 2000. The Corps has done extensive studies of the feasibility, environmental effects and benefit of removing Snake River dams, and has conducted a preliminary assessment of John Day Dam drawdown.

We also did not examine configuration options for FERC-licensed projects, but recognize that changes at these projects may benefit fish. For example, removal of the Hells Canyon Complex could provide significant benefits to Snake River stocks. Opportunities for fish passage improvements at FERC-licensed projects should be considered during relicensing processes. Projects undergoing relicensing proceedings in the near term include Pelton and Round Butte Dams, Hells Canyon Complex and three Mid-Columbia PUDs (Rocky Reach, Priest Rapids and Wanapum).

Option 1

Current Program

This option would continue on the present path of ongoing improvements to the system, with roughly the existing annual level of investment continuing into the future. Both system operations and configurations under this alternative would continue as they have been developed under the NMFS 1995 and 1998 Biological Opinions, and USFWS Biological Opinions on resident fish. As such, this might be termed the status quo option, because it continues the present program. However, this option does not represent a static-state in terms of measures to improve fish survival. It focuses on addressing identified problem areas where potential fixes are relatively well understood. It also anticipates that evaluations of fish passage measures that are less well understood will continue to better inform potential future decisions. In addition, the current program will ensure that fish passage facilities are adequately maintained and operated into the future. This option leaves open the possibility that dams may be breached in the future. It corresponds to Framework Alternative 4. The rationale for this approach is based on the premise that further improvements to passage will not increase fish survival, and that indirect mortality from the hydropower system is not large. However, this option also provides for additional studies to test this premise. Potential incremental fish survival improvements that may be associated with additional measures and investments would also be studied. This option does not preclude future decisions on additional investments in passage measures if deemed appropriate based on survival evaluations, but it does not plan on them from the outset except as listed below.

Columbia River Configuration Measures —
The Corps would continue to evaluate improvements to fish passage facilities at McNary, John Day, The Dalles and Bonneville dams, with total investments at about the same level or less than in the past 5 years. The current program will improve adult passage by adding emergency backups for the auxiliary water supply at fish ladders, and other measures to reduce **adult fallback** or improve adult passage. Juvenile passage evaluations and improvements include:

- continued development and testing of a surface bypass at John Day and Bonneville dams;
- continued investigation of the effectiveness of extended length fish screens at John Day Dam;
- continued investigation of the effectiveness of extended screens, alterations to the **juvenile bypass outfall**, and/or a surface bypass at Bonneville Dam first and second powerhouses;
- continued investigation of relocating the **sluiceway outfall** at The Dalles Dam;
- continued investigation of installing additional and/or modified spillway deflectors at all four dams;
- powerhouse turbine improvements such as **minimum gap runners** at Bonneville Dam's first powerhouse, if proven effective in improving turbine passage survival;
- flow deflectors at Chief Joseph Dam.

Columbia River Operational Measures —
Operations for flow, spill and transportation are essentially the same as those specified in the 1995 and 1998 Biological Opinions. Modifications include minimum discharge requirements for fall chinook and chum salmon spawning and rearing needs below Bonneville Dam. In addition, there would be a reduction in the fluctuation of flows from Priest Rapids to reduce fry stranding and stabilize riparian areas. Federal agencies would continue to use the existing volume of water for management of flows for the benefit of various fish stocks and species of concern.

Snake River Configuration Measures —
Fish passage configuration measures include improving emergency water supplies for adult passage systems, relocating the bypass outfall at Lower Monumental Dam, and construction of a trash shear boom at Little Goose Dam.

Snake River Operational Measures — Operations for flow, spill and transportation are essentially the same as those specified in the 1995 and 1998 Biological Opinions. The federal agencies would continue to use the existing volume of water for flow augmentation from the upper Snake River Basin to benefit summer migrants.

Option 2

Aggressive Program

In this option, we assume that the investments in the current program for improved fish passage facilities, such as surface bypass, will be successful and are continued to increase passage survival. The primary difference in configuration measures between this alternative and the present program is that the federal agencies would seek increased funding to pursue more aggressive implementation of measures to improve passage survival. This option would also include more aggressive operational measures for flow and spill. The federal agencies would seek increased flow augmentation from Canadian reservoirs and improved water quantity and quality from the upper Snake River. Spill at many projects may be expanded to daylight hours. For purposes of analysis, this option assumes that aggressive measures are implemented and limited by biological criteria only (i.e., measures are assumed to not be limited by physical constraints such as the transmission system, dissolved gas supersaturation, etc.). The feasibility of efforts to eliminate such constraints has not been assessed nor have decisions on implementation of these measures been made. Similarly, constraints on system operations should also be evaluated, such as for flood control. This option corresponds to Framework Alternative 5.

There are generally three potential reasons why an aggressive approach might be pursued:

(1) additional improvements in *direct survival* are deemed necessary and appropriate relative to their contribution to population growth and recovery;
(2) improvements in system configurations or operations are expected to reduce *indirect* hydropower system-related mortality and such improvements are deemed necessary to contribute to population growth and recovery; and/or
(3) improvements in system configuration or operation are implemented to reduce economic effects of current conditions while providing equal or greater protection from direct and indirect mortality factors than current conditions.

Opportunities to dramatically improve direct survival through the system are limited, about a 5-10 percent increase in the survival of juveniles migrating in the river. But if juvenile and adult fish suffer latent mortality because of their experiences in the hydropower system, measures under this option may reduce this indirect mortality by reducing delay and trauma to fish as they pass through the system.

Columbia River Configuration Measures – The Corps would continue to improve fish passage facilities at McNary, John Day, The Dalles and Bonneville dams. The aggressive program includes all measures specified for the current program and, depending on the results of investigations, may include some or all of the following measures:

- installation of surface bypass, either at the spillway or powerhouses, at McNary, John Day and Bonneville dams;
- installation of extended length screens at John Day and Bonneville dams;
- relocation of the sluiceway outfall at The Dalles Dam;
- additional and/or modified spillway deflectors at all four dams;
- potential powerhouse turbine improvements such as minimum gap runners
- flow deflectors or additional turbines at Libby Dam for dissolved gas abatement.

Columbia River Operational Measures — Efforts would continue to acquire additional water from Canadian reservoirs, implementation of “Variable Q” flood control operations at Libby and Hungry Horse dams to protect resident fish, and meet minimum discharge requirements for fall chinook and chum salmon spawning and rearing needs in the Hanford reach and below Bonneville Dam. In addition, fluctuation of flows from Priest

Rapids would be reduced to limit fry stranding and stabilize riparian areas. Integrated Rule Curve (IRC) operation at storage dams would be further evaluated and implemented based on tradeoffs in benefits to resident fish and effects on salmon habitat and other system operation purposes.

Snake River Configuration Measures — Additional improvements include spillway deflectors, surface bypass, either at spillways or powerhouses, modifications to the Lower Granite Dam juvenile fish facility and two to five additional transport barges.

Snake River Operational Measures — Additional spill may be provided at three projects. Additional water would be sought for temperature control and flow augmentation. Details of when and how much water would be provided and sources for it have not been identified at this time. USBR has conducted a study of the impacts of acquiring additional water in the upper Snake River; it is available on their Web site at *www.pn.usbr.gov*.

Option 3

Breach Lower Snake River Dams

Option 3 improves conditions for Snake River stocks by removing the dams that block their passage in the Snake River. All four salmon and steelhead ESUs in the Snake River are listed as threatened or endangered, and represent one-third of the listed ESUs in the basin. Under this option, which corresponds to Framework Alternative 3, Snake River dams are breached as soon as Congressional authorization and appropriation occur. During the interim period prior to breaching, minimal or no investments are made to improve the configuration of Snake River dams. The rationale for this alternative is that passage through the hydropower system, whether in barges or in the river, causes direct and indirect mortality to Snake River juveniles. The best way to eliminate this mortality is by removing the dams.

Configuration and operational measures in the Columbia River would occur at the same rate as under the present program. In the Snake River, operational measures would continue to include flow augmentation from Dworshak Reservoir as needed to moderate temperatures in the lower Snake River.

3.4.7 Evaluation of Options

In developing the three hydropower options, we relied on many existing sources of information and analysis. Notable sources included the Multi-Species Framework Project, the Lower Snake River Juvenile Fish Migration Feasibility Study, the Corps Columbia River Fish Mitigation Project, and the work of the regional System Configuration Team and its related technical coordination groups. We worked closely with the Framework Project to jointly develop specifications of the options and coordinate evaluation and new analysis such as biological considerations in the CRI and EDT, and hydroregulation studies of storage project Integrated Rule Curves.

Biological Evaluation

To date, the biological analysis reflects work conducted by PATH and the CRI for three ESUs in the Snake River. Additional information is expected as further CRI evaluations of the other Columbia River listed salmon and Framework EDT analyses are conducted. A summary of the CRI/PATH results for the Snake River is reported below.

Snake River Spring/Summer Chinook

Option 1: Nearly one-half of PATH simulations under current hydrosystem operations met 48-year recovery standards. CRI analyses indicate that there is substantial risk of spring/summer chinook populations meeting quasi-extinction thresholds under current conditions in both the long (100 years) and short (10 years) term. The option of waiting until we learn more about **extra mortality** or delayed mortality associated with transportation thus carries with it additional risk of extinction for these species.

Option 2: PATH analyses indicate that there is a slightly lower probability of reaching recovery standards under scenarios that rely on increased transportation than under current operations. (This is due largely to assumptions about delayed mortality associated with transportation.) However, recovery standards were achieved in 45 percent of simulations.

CRI analyses predict that projected increases in survival of smolts through the migration corridor, or of adults migrating upstream from Bonneville Dam, will result in an increase in population growth rate of only 1 percent each (approximately 2 percent combined). Since an average population growth rate increase of 12 percent is necessary to reduce the risk of extinction for this species to 1 in 10 in the next 100 years, predicted passage system improvements alone do not substantially reduce the risk of extinction for this species. Even if downstream survival of outmigrating juveniles were raised to 100 percent (which is the maximum possible hydropower system improvement with respect to transportation and bypass options), that demographic change would be insufficient to attain high enough annual rates of population growth to adequately reduce that extinction risk by itself. However, if alterations of bypass, spill, or transportation systems increase survival below Bonneville Dam (i.e., reduce indirect mortality), then larger benefits for population growth could be realized.

Option 3: One hundred percent of PATH spring/summer chinook salmon simulations under dam breaching met 48-year recovery standards. CRI analyses, however, suggest that dam breaching alone will be insufficient to reduce extinction risk for this ESU. Current projections show that for spring/summer chinook, dam breaching alone is likely to result in an increase of population growth rate of about 5 percent, due to reduced mortality of migrating smolts and spawners. For this scenario, the improvements associated with breaching were assumed to result in a Bonneville-to-Basin survival of 80 percent, a downstream survival of 62 percent and an increase in estuarine survival of 30 percent (due to reductions in indirect mortality). However, as with passage systems, if dam breaching increases survival of fish below Bonneville Dam, then substantial increases in population growth rate could be achieved. For example, dam drawdown could also result in increases in habitat availability and possible improvements in survival during freshwater rearing (there is some evidence that young may experience elevated mortality when reared in reservoirs.) Dam breaching could also alter patterns of **nutrient cycling** and replenishment that in turn influence productivity. There could even be delayed effects of dam breaching in terms of increased fitness of fish that would be subtly manifested throughout the life cycle (as opposed to discrete improvements in the survival of any isolated stage).

How effective dam-breaching might be in recovering Snake River spring/summer chinook depends to a large extent on whether juvenile fish suffer indirect mortality as a result of their experience in the hydropower system. This mortality is considered “indirect” because it does not occur immediately in the hydropower corridor but later, in the estuary or ocean. Indirect mortality suffered by *transported* fish is referred to as “differential delayed mortality” and is represented in PATH equations as “D.” In addition, some theorize that *both transported and in-river* migrants suffer indirect mortality caused by the Snake River dams. Indirect mortality suffered by both groups is referred to in PATH documents as “extra mortality.”

The PATH projections assume transported fish suffer high indirect mortality as a result of the transportation experience. The CRI projections do not assume significant indirect mortality for transported fish. This difference in treatment of indirect mortality is one of the primary reasons that PATH and CRI analyses appear to reach different conclusions regarding how effective dam-breaching might be in recovering Snake River spring/summer chinook. CRI analyses do not incorporate assumptions about extra mortality. Rather, they highlight how much survival in later life stages (such as the estuary) must be improved as a result of dam breaching for that action alone to be effective.

Snake River Fall Chinook

Options 1 and 2: PATH did not explicitly model current operations because most fall chinook are currently transported. Therefore, current operations are assumed to be virtually identical to the maximum transport options. PATH analyses indicate that these maximum transport options meet survival standards in all cases, and 48-year recovery standards in some cases. However, recovery standards were not met in model runs where delayed mortality due to transportation was assumed to be high. (Note that very few runs were conducted for these analyses.

CRI extinction risk analysis indicates that there is a significant risk of extinction over the next 100 years if current conditions are maintained (or worsened). An approximately 4 percent increase in population growth rate is expected to lower the probability of quasi-extinction within 100 years to one in a hundred.

Option 3: PATH analyses indicate that dam breaching has the highest probability of achieving survival and recovery probabilities for fall chinook across all assumptions. Because passage data for fall chinook are limited, the CRI was limited in its ability to address the effects of dam breaching. However, the majority of effects of dam breaching would likely occur in the first year of life, which includes both downstream migration and "post-Bonneville Dam" survival in the estuarine environment (where latent effects of dams are likely to accrue.) We examined the percent increase in population growth rate expected to result from a broad range of potential changes in first year survival. This level of improvement in population growth rate could be achieved with a less than 20 percent increase in first year survival. Although the precise effect of removing the lower Snake River dams on first year survival is not known, by analogy with spring/summer chinook, it is not unreasonable to anticipate a 20 percent increase in first year survival could be achieved. Breaching would also increase the number of river miles available to fall chinook for spawning by as much as 70 percent, and may therefore increase the carrying capacity for this species. Such an increase may be important for the ultimate recovery of this species.

Snake River Steelhead

Option 1: PATH did not model steelhead populations, but assumed that results from spring/summer chinook would be applicable to this species. CRI analyses indicate that steelhead have a very low risk of extinction in the short-term, due to relatively high current population levels. However, they appear to have a very high risk (over 90 percent) in a 100 year time frame of reaching the quasi-extinction threshold, indicating that current operations are inadequate to minimize extinction risk for this ESU.

Option 2: The impact of system improvements is much harder to evaluate because passage survival rates are lacking for this ESU.

Option 3: Again, the impact of dam breaching is harder to evaluate due to their complex life cycle and the lack of passage survival information. By analogy with other salmonids, it is not unreasonable to think that survival could be increased by 20 percent with dam removal, which would minimize the risk of reaching quasi-extinction thresholds.

Snake River Sockeye

Snake River Sockeye are currently so depleted that no analysis can be conducted.

Other Columbia Basin ESUs

Other Columbia Basin ESUs have not yet been analyzed. Improving passage systems at the four lower Columbia dams will benefit mid- and upper-Columbia stocks to an unknown degree. In addition, increased spring flows may result in unquantifiable benefits to all stocks, due to changes in estuarine conditions.

Other Considerations

Social and Economic Evaluation

Implementation costs for configuration measures have been estimated for the three options. Also, considerable analysis has been conducted in related studies [the Lower Snake River Feasibility Study and its Drawdown Regional Economics Workgroup (DREW)] and a report on tribal conditions "Tribal Circumstances and Perspective Analysis of Impacts of the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs, and Shoshone Bannock Tribes") on economic and social effects of the same alternatives or alternatives similar to those identified in the options. Additional analysis is expected in the Framework Report. A very brief summary of implementation costs (current price levels) and economic effects is presented here.

- ***Current program*** — Implementation cost estimates for configuration measures range from about $185 million, for continued investigation and implementation of known improvements, to $800 million if development and evaluations lead to full implementation of the identified potential measures. System operation economic effects are as currently occurring. Even currently planned operations have serious social and economic impacts at Dworshak reservoir in Idaho and lesser impacts at reservoirs in Montana, Washington and the upper Snake River in Idaho.

- ***Aggressive program*** — Implementation cost estimates for configuration measures range from about $850 million to $1 billion. System operation related economic effects have not been evaluated at this time, including transmission system reinforcement requirements or effects and additional upper Snake River water acquisition costs. Increased flow augmentation would increase impacts on upstream reservoirs and upstream water users.

- ***Breach Lower Snake River Dams*** — Implementation cost estimates for configuration measures range from about $1.2 billion, assuming limited additional passage improvements are made in the Lower Columbia, to about $1.9 billion if studies and decisions lead to implementation of major passage measures at the four lower dams. As compared to the current program, the average annual cost of this option is $246 million. Direct implementation expenditures would average approximately $50 million annually, and economic costs are as much as $271 million for power, $24 million for navigation, and $15 million for irrigation, annually. A benefit in recreation is estimated at $82 million annually. This option would have significant social and economic impacts on lower river users. These include, among others, barge operators, irrigators and recreationalists. Lewiston, which is now a seaport, would no longer have barge traffic to and from the Pacific Ocean. Irrigators in the lower Snake River reservoirs would no longer have access to irrigation water without costly pumping. This option may also result in significant short-term local job growth during implementation, as well as long-term economic benefits derived from increased tourism, recreation, and fishing. This option may also result insignificant short-term job growth during implementation. Annual benefits to commercial fishing and avoided costs are $2 million and $29 million, respectively.

Ecological Effects

Although not specific to the options considered here, an analysis of the physical effects of implementing IRCs at Libby and Hungry Horse projects was conducted. The IRCs, proposed by the state of Montana, are intended to benefit resident species. The analysis, reported in the Hydropower Appendix, indicates on average that there would be higher reservoir elevations at Libby and Hungry Horse in the fall (4 to 14 feet), and spring elevations would be generally higher at Libby and slightly lower at Hungry Horse compared to existing operations. Flows at McNary would be slightly higher from November to May (-4 **kcfs** to +7 kcfs) and slightly lower the rest of the year (-10 kcfs in July).

The U.S. Fish and Wildlife Service in its Coordination Act Report evaluated the ecological impacts of the different hydropower options. Under Options 1 and 2, the lower Snake River would continue to present passage problems for resident fish such as white sturgeon, segregating their populations. For terrestrial species, riparian corridors would continue to be discontinuous and dominated with non-native species mainly in artificial islands maintained with irrigation. Mitigation for wildlife losses from the construction of the four dams would continue to remain at about 75 percent of the estimated losses.

Under Option 3, more natural river conditions would be established, benefiting ecosystem processes and native resident aquatic species. The physical condition of the river should be able to return to a near natural condition. A major portion of the basin would become completely unregulated, allowing natural rhythms of spring runoff to occur. A more natural flow regime would help maintain and restore timing, variability, and duration of flood plain inundations, with associated benefits for wetlands and other habitats. Restoration of other ecosystem components, such as the re-establishment of a network of complex and interconnected habitats and processes, would take several years to decades.

In the long term, most native resident fish species would benefit from returning the lower Snake River to a free-flowing river since most are broadcast spawners and depend on flowing water for successful reproduction. White sturgeon subpopulations would no longer be artificially isolated and numbers would increase due to improved spawning and rearing habitat and increased food abundance. Use of the area by species that prefer cold water, such as bull trout, mountain whitefish, and rainbow trout, would increase as connectivity between tributaries is improved and water temperatures are cooler for prolonged periods. Most non-native species would decrease in abundance from loss of their preferred habitats. Improved riparian habitat conditions would result in positive effects for several groups of wildlife (e.g., game birds, raptors, other non-game birds, big game animals, small mammals, and bats). Improved habitat conditions would also benefit some species of waterfowl, fur-bearers, amphibians and reptiles. Most of the existing wetlands (about 300 acres) would be lost, with a reduction or elimination of species that rely on them.

Effect on Tribal Rights

Under Options 1 and 2, which leave Snake River dams in place, the dams would continue to affect the fisheries resources of lower river tribes, as described in the section on Biological Evaluation. Snake River fall chinook, in particular, are significantly affected by inundation of spawning areas and migration blockage. Steelhead are also affected by migration blockage. Depressed populations of Snake River fall chinook and steelhead will continue to limit tribal access to abundant runs of fall chinook returning to the Hanford Reach, upstream of McNary Dam. There is debate on the degree to which dam passage affects Snake River spring/summer chinook, and the degree to which those effects can be mitigated by the smolt transportation program.

Option 2 may also affect tribes with interests in reservoirs in Washington and Montana. If increased flow augmentation came from these upstream reservoirs, it could affect the productivity of resident fish in the reservoirs, as well as fish in rivers immediately below the reservoirs. Increased flow through Lake Roosevelt, behind Grand Coulee Dam, might also affect productivity of resident fish there.

Option 3, which removes Snake River Dams, would likely significantly increase productivity of Snake River fall chinook and steelhead and would also increase productivity of Snake River spring/summer chinook to an unknown degree. This option may also affect tribal cultural resources that were inundated when the reservoirs were created.

3.4.8 Implementation Issues

The 1995 NMFS Biological Opinion refined the structure for coordinating the decisions on configuration and operation of the FCRPS. That structure includes a group of program managers, known as the Implementation Team, which meets monthly. The structure contemplated in the BO also included an Executive Committee that would meet as needed to resolve disputes from the Implementation Team. That Committee has not met in over a year and there appears to be little interest among the state and tribal managers to participate in such a committee. Under the Implementation Team are several technical workgroups established to address different issues. The Technical Management Team meets weekly during the migration season to set hydropower operations. The System Configuration Team meets weekly and establishes priorities and schedules for capital improvements at the projects. The Water Quality Team provides scientific and technical recommendations on two critical water quality parameters: dissolved gas and temperature. In addition to and in conjunction with these teams, there are existing groups that coordinate technical and programmatic aspects of regional activities in the hydropower arena. These include the Corps' Fish Passage Operation and Maintenance Committee, Fish Facilities Design Review Workgroup, Studies Review Workgroup, and the workgroup for the Fish and Wildlife Funding MOA on BPA investments for fish and wildlife recovery.

Annual flow management plans to manage water releases for Kootenai River white sturgeon during April through August are based on coordination among the Corps, BPA, NMFS, USFWS, USBR and other coordinating entities such as the state of Montana, Kootenai-Salish Nation, British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries, and BC Hydro. Implementation of annual flow management plans for white sturgeon and the 1999 flows for bull trout have occurred through the Technical Management Team to ensure that anadromous and resident fish needs are addressed in FCRPS operations decisions. The federal agencies believe this type of intense coordination within a hierarchical structure is appropriate and recommend it continue. There are a number of opportunities for improvement, including:

- Policy oversight – We recommend using the newly formed Columbia River Basin Forum as the policy oversight body to consider disputes that cannot be resolved at the Implementation Team level.
- Participation – Consistent participation would improve decision making and timely implementation of actions and measures. Federal/Nonfederal coordination – Presently there is informal coordination of activities at FERC-licensed projects, e.g., configuration measures at Mid-Columbia projects, with federal efforts at downstream dams. Although there is a Mid-Columbia Coordinating Committee, there could be better links established to ensure that coordination of programs and technology transfer occurs.
- In-season Management – Improved ability to make decisions (see Hydropower Appendix).
- Research framework – A multi-year regional research plan identifying priorities and responsibilities, and enabling coordination of programs and budgets, could improve efficiency and enhance integration of research results into decision making.
- Performance Monitoring – Better monitoring to ensure biological and implementation performance standards are being met.
- Advance Planning – There should be better coordination to plan ahead on operations.

3.4.9 Performance Measures

Some performance measures for hydropower are relatively straightforward, while others are more difficult because of questions about indirect mortality. Performance measures include the following categories:

Juvenile system survival – the primary method for measuring the survival of juveniles through the entire hydropower corridor or specific reaches is PIT-tags. There is presently an extensive PIT-tag program to measure survival of Snake River fish. Because this method provides such a powerful tool for learning about fish survival, PIT-tag studies should be expanded to other parts of the basin.

Direct juvenile project survival – there are a number of methods for measuring project passage and survival, including PIT-tags, radio tags, and hydroacoustics. By measuring survival at individual projects, it is possible to identify adverse conditions and develop passage improvements. Understanding project survival may be useful in determining priorities for action.

Adult project survival – adult movements can be measured using radio tags, and eventually PIT-tags in adult passages, but it is difficult to attribute adult losses to a particular project. Fish that fall back through a dam may have wandered past their natal stream and simply be moving back downstream, or the fallback may be due to dam **hydraulics**. Delay and stress in passing dams may cause indirect mortality, which is difficult to measure and attribute to a particular dam or reach. Performance measures for adult ladders can be developed for water temperature in ladders, delay in entering/ascending ladders and fallback from the forebay.

Juvenile fitness – This measure may help understand the indirect mortality effects from the hydropower system and other factors. There are a number of measures of juvenile fitness, though establishing meaningful criteria is difficult. Juvenile fitness may be the result of conditions in rearing areas or annual variations in the migration corridor. It is also difficult to correlate fitness criteria with indirect mortality caused by dam passage. Measures of juvenile fitness include delay at dams (i.e., set a standard for and measure how long juvenile fish take to pass the dams); level of **descaling**; and signs of **gas bubble disease**.

Resident fish survival – Performance measures related to hydropower for Kootenai River white sturgeon include: a minimum number of naturally produced juveniles sampled at more than one year of age in each year class; the number of year classes in a 10-year period that produce the minimum number of juveniles sampled at more than one year of age; and demonstration of the repeatability of in-stream environmental conditions necessary to produce juveniles at more than one year of age. Performance measures for bull trout and other resident fish species would include measures of survival at various life history stages.

3.4.10 Research, Monitoring and Evaluation

The current program of monitoring and researching project and system survival should be continued and expanded. In particular, the federal agencies are continuing to explore research, monitoring and evaluation approaches to address key uncertainties in a timely manner. These uncertainties can generally be described as the effects of passage through the FCRPS that might occur within or as a result of the hydrosystem, but that are thought to be manifested outside the system. Four potential effects of passage should be addressed in a hydropower monitoring and evaluation framework: 1) effects of multiple bypass passages; 2) effects on adult reproduction; 3) delayed mortality associated with transportation; and 4) estuarine and early ocean survival.

3.4.11 Key Uncertainties

A key priority should be resolving the uncertainty about indirect mortality – to what extent it exists, and, if it does, whether it can be addressed through project improvements such as surface collectors and spill, or whether dam removal is the only means to address it. This uncertainty is important regardless of whether a decision is made to remove Snake River dams. Even with Snake River dams removed, all upriver fish must still migrate through the four federal dams in the lower Columbia River. Upper Columbia fish will still face seven, eight or nine dams on their journey through the Columbia (four to five public utility dams, plus the four federal dams).

4. Integrated Alternatives

4.1 Biological Considerations

To construct integrated alternatives, the Federal Caucus considered the available scientific analyses. These include the Cumulative Risk Initiative (CRI), developed by the Northwest Fisheries Science Center of NMFS, and the Plan for Analyzing and Testing Hypotheses (PATH), a collaborative effort of the state fishery agencies, tribes and federal agencies. The CRI has estimated the risk that salmon and steelhead ESUs in the Snake River will reach a quasi-extinction threshold, defined as one fish or fewer returning in any single year. Analyses for other basin ESUs are underway. As a result of assumptions in the modeling, the CRI projections may underestimate the actual risk of extinction. Results of both modeling efforts should be used with caution. Models contain many assumptions that might be wrong. The farther out the projection, the less certain the results. The 100-year projections should accordingly be viewed as highly uncertain. The information from these analyses is presented below.

4.1.1 Snake River ESUs

Snake River spring/summer chinook. There are seven "index" populations of Snake River spring/summer chinook (of a total of 35-40 populations). Two have a serious risk (1 in 10) of reaching the quasi-extinction threshold in 10 years. All populations have a greater than 30 percent chance of reaching the threshold within 100 years if the current trend in the population's productivity continues. CRI modeling suggests that to reduce the short-term risk for these stocks to 1 in 100 would require a significant change in growth rate (e.g., 25 percent for the population in the worst shape). Other populations require a 5-20 percent change in growth rate. There are few immediate actions that can reduce the short-term risk since harvest rates are already very low (5-7 percent). Implementation of hatchery conservation programs may therefore be an important strategy in maintaining these stocks until long-term actions begin to take effect.

Reducing the risk of reaching the quasi-extinction threshold in 100 years to more acceptable levels requires a 12 percent change in growth rate on average across populations. The CRI analysis indicates that removing Snake River dams by itself would yield little improvement in growth rate, unless there is significant delayed mortality associated with transportation and/or dam passage. Even if downstream survival were increased to 100 percent, the rate of population growth would only increase by 4 percent. Eliminating harvest would change the growth rate by only about 1 percent.

CRI analyses indicate that there is no single action that will be sufficient to substantially reduce extinction risk for this ESU, unless there is substantial indirect mortality attributable to the hydropower system or transportation methods. Rather, for Snake River spring/summer chinook to survive in the long term a combination of improvements in all four Hs is required. To begin to determine the magnitude of improvement in each H necessary to increase population growth rates and reduce extinction risk, CRI conducted several numerical (theoretical) experiments. (Delayed mortality due to transportation was assumed to be low in all cases.) First, CRI analyzed the combined effect of leaving dams in place, but increasing first year survival by 32 percent, maximizing the proportion of juveniles transported, increasing survival in the estuary and near-shore ocean by 10 percent, and eliminating harvest. Together, these changes resulted in a 14 percent increase in population growth rate, which would substantially reduce the risk of extinction for this ESU. However, the hypothetical increases in survival during early life stages are relatively large; and actual increases in survival due to specific management actions affecting freshwater or estuarine survival have not yet been determined. CRI also analyzed the combined effect of removing dams, coupled with no harvest and an increase in estuarine survival of 10 percent. This scenario increased the population growth rate by about 8 percent, indicating that additional improvements would be necessary to substantially reduce extinction risk. Again, actual increases in survival due to specific management actions affecting early life survival have not yet been determined.

PATH modeling suggests that Snake River spring/summer chinook come close to reaching the survival goal, and have some chance of reaching the recovery goal, if harvest is held to the present low harvest rate as runs rebuild. PATH modeling also suggests that removal of Snake River dams can achieve NMFS' survival and recovery goals. PATH models assume a range of values for delayed mortality associated with transportation and/or dam passage. The analyses done by the PATH group show no appreciable benefit from hatchery or habitat actions. PATH modeling shows increasing population trends for all future actions analyzed.

The best prospects of avoiding short-term extinction and achieving recovery of Snake River spring/summer chinook appear to be combinations of actions in habitat restoration, harvest limits, predator control, and hydropower improvements (including dam breaching). With or without dam removal, harvest restrictions may be needed for many years.

Snake River fall chinook have less than a 1 percent likelihood of reaching the quasi-extinction threshold in the short term, but a higher likelihood of reaching that threshold over the long term (6-17 percent). CRI modeling suggests that a modest improvement in growth rate (around 4 percent) may be needed to reduce the long-term probability of extinction to a more acceptable level.

Although the precise effect of removing the Snake River dams is unknown, by analogy with spring/summer chinook, this change in growth rate might be achieved by removing dams or by improving collection efficiency so that more smolts are transported (assuming delayed mortality associated with transportation is not significant). The CRI concluded there was not enough information to model the effects of dam removal, but noted that a 20 percent increase in survival during the first year would be enough to result in a 4 percent change in growth rate. For fall chinook, this first year includes freshwater rearing, migration through the hydropower corridor, residence in the estuary and transition to the ocean. It is not unreasonable to expect a

20 percent increase in first-year survival could be achieved. In addition, breaching dams may increase available spawning habitat below the Hells Canyon dams by as much as 70 percent which may be important given that 90 percent of historical fall chinook spawning habitat was above the Hells Canyon dams.

The needed change in growth rate could also be achieved by reducing the combined ocean and in-river harvest rate by 50 percent, or by reducing either one by 75 percent. Combined harvest rates in recent years both in the ocean and the river have been reduced significantly from a high in the 1980s of about 80 percent to the present level of about 50 percent. Because fall chinook spawn and rear in lower tributary streams and the main river channel, opportunities to improve fall chinook habitat are limited, short of breaching lower Snake River or Hells Canyon dams, although improvements in water quality and quantity from the upper Snake River could benefit fall chinook survival. Hatchery fish straying into the Snake River may have affected fall chinook in the past, but that problem has largely been controlled.

PATH modeling suggests that Snake River fall chinook reach recovery goals if harvest is significantly decreased, if dams are removed, or if transportation is stopped (assuming there is significant delayed mortality associated with transportation).

In the long term, either significant improvements in survival in the hydropower corridor or significant reductions in harvest rates may be needed to recover this ESU.

Snake River steelhead have a less than 1 percent likelihood of reaching the quasi-extinction threshold in 10 years, but their rate of decline has been so steep since 1980 that they are projected to have a greater than 90 percent likelihood of reaching that threshold in 100 years.

CRI modeling suggests that reducing the probability of reaching that low threshold in 100 years to a more acceptable level, requires a 10 percent change in growth rate. A long-term reduction in harvest rates to 5-10 percent would provide a sufficient change in growth rate to result in a 1 in 100 probability of reaching the quasi-extinction threshold in 100 years. Harvest rates have been reduced by about half in recent years (from 32 percent to 16 percent) as a result of ESA concerns. By analogy with other salmonids, it is not unreasonable to expect that dam removal could change survival by 20 percent, which would increase annual rates of population growth and substantially reduce the risk of reaching the quasi-extinction threshold. PATH did not model Snake River steelhead.

There may be opportunities to improve steelhead habitat, although this would require further investigation. There is a large amount of steelhead hatchery production in the Snake River that may affect naturally produced steelhead, although there is a great deal of uncertainty about this.

Unless there are significant benefits that can be obtained from habitat and hatchery improvements, either dam removal or long-term reductions in harvest rates may be needed to recover this ESU.

Snake River sockeye cannot be modeled because there are so few of them. They are now kept from extinction by a captive broodstock program. If at some point in the future their numbers increase, it may be possible to analyze them with models. Because Snake River sockeye have a life history similar to Snake River spring/summer chinook, past analyses for chinook have often been applied to sockeye. If this comparison is accurate, Snake River sockeye also have similarly dim prospects of recovery without dramatic improvements in all stages of their life cycle.

4.1.2 Upper Columbia River ESUs

Upper Columbia River steelhead are listed as endangered. They are particularly complicated to model because they are maintained primarily through hatchery production. Preliminary QAR modeling suggests steelhead have no significant likelihood of dropping below quasi-extinction levels so long as they continue to be sustained by hatchery production. Projections of future performance without hatchery production depend on assumptions about how effective hatchery fish have been at reproducing in the wild. QAR analysis indicates that assuming hatchery fish have been equally as effective as naturally-spawning fish, this ESU has a 100 percent probability of reaching a quasi-extinction level of 2 fish in one year within 41-72 years. Reducing this risk to 5 percent requires an improvement in productivity on the order of 35-42 percent, assuming recent environmental conditions continue into the future.

The QAR workgroup has not yet analyzed the likely sensitivity of this ESU to survival improvements in different life stages. It is premature to draw conclusions about what actions will result in the greatest improvements. Given the large measure of improvement needed, however, it is likely there will need to be significant contributions from all of the Hs to recover upper Columbia steelhead.

Upper Columbia River spring chinook are listed as Endangered. Detailed assessments of extinction risks are still being developed. Initial results, using methods similar to those employed in the CRI analyses, project high quasi-extinction risks for these runs in the absence of hatchery supplementation. Model results indicate that the supplementation programs being implemented to support these runs could reduce the risk of falling below quasi-extinction levels to negligible levels. Based on preliminary results, reducing the risk of quasi-extinction to below 1 in 100 at 100 years would require a 28-35 percent improvement in productivity in the absence of hatchery supplementation.

The QAR workgroup has not yet analyzed the likely sensitivity of this ESU to survival improvements in different life stages. It is premature to draw conclusions about what actions will result in the greatest improvements. Given the large measure of improvement needed, however, it is likely there will need to be significant contributions from all of the Hs to recover upper Columbia spring chinook.

4.1.3 Other ESUs

The CRI is continuing model work on additional ESUs. Preliminary modeling should be completed for upper Columbia chinook and steelhead by the end of this year and for upper Willamette chinook and steelhead by the beginning of next year.

4.2 Integrated Alternatives

There are a number of ways to combine options from the different Hs to arrive at integrated alternatives. Those displayed below are certainly not an exhaustive enumeration of all the possibilities. The alternatives are all intended to improve survivals of Columbia Basin salmon and steelhead populations over the long term, although some have more certain benefits than others. It was the intention of the Federal Caucus to display possible alternatives that have some likelihood of contributing significantly to recovery of listed populations.

A fundamental point made by these alternatives is that the Federal Caucus' assessment is that current levels of activities in the four Hs will be inadequate to provide significant confidence in salmon and steelhead recovery. From that basis, packages of measures have been arrayed to begin the discussion about how best to approach salmon recovery. The purpose of the alternatives is to further discussion and debate of these and other alternative combinations that have significant potential for contributing to recovery of salmon and steelhead populations.

For reference, the following table summarizes the options presented for each H.

The alternatives describe broad policy choices for salmon and steelhead recovery, and are intended to stimulate public discussion and allow the public early access to the thinking process within the Federal Caucus. They do not represent the only combinations of options that could provide recovery, nor do they represent preferred federal alternatives.

4.2.1 Alternative A
Dam Removal

Habitat – Option 1
Coordinate and Prioritize Federal Actions

Harvest – Option 1
Fishery Benefits During Recovery

Hatcheries – Option 1
Currently Planned Programs

Hydropower – Option 3
Breach Lower Snake River Dams

Under this alternative, the decision is made now to breach Snake River dams and the necessary congressional authorizations are pursued. The primary reliance for recovering Snake River fish is on breaching. There is little increase in effort to improve habitat conditions on nonfederal land, as resources would be focused on dam breaching. Because of the expected benefit in fish productivity from breaching, harvest is constrained by weak stocks, but is allowed to increase as runs increase. Since most conservation hatchery programs are aimed at Snake River fish, there is no need to increase the conservation program, and existing resources would be shifted to the Columbia River ESUs. Similarly, the expected increase in productivity of wild Snake River fish means there is less concern about the possible harmful effects of mitigation hatchery production on wild fish in the Snake River. This alternative does not improve survivals for fish outside of the Snake River beyond those improvements that would result from programs already in place.

Table 5 - Summary of All H Options

Specific H	#1	#2	#3
Habitat	**Coordinate and Prioritize Actions** • Increased federal coordination • Some increased habitat protection • Emphasis on assessment and planning	**Coordinate Regional Plans** • Significantly improve habitat • Additional federal funding • Increased federal-nonfederal coordination	**Increased Federal Role under Clean Water Act and ESA** • Moderate to significant improvement in habitat • Additional federal regulation of nonfederal actions (re: ESA, CWA)
Harvest	**Fishery Benefits During Recovery** • Recently negotiated Pacific Salmon Treaty • Allow some increase in in-river fisheries as runs rebuild (e.g., sliding scale) • Tribal priority	**Fixed In-river Harvest Rates (1999 levels)** • Recently negotiated Pacific Salmon Treaty • In-river fisheries held at 1999 rates until recovery goals are met • Tribal priority	**Conservation Fishery Levels** • Reduce ocean fisheries • In-river mixed stock at conservation levels only • Seek additional Canadian restrictions • After 10 years, allow increases
Hatcheries	**Currently Planned Programs** • Currently planned conservation hatchery programs • Currently planned Improvements in mitigation hatchery programs	**Increase Conservation Programs** • Increased conservation hatchery programs • Currently planned Improvements in mitigation hatchery programs	**Increase Conservation Programs and Significantly Decrease Mitigation Programs** • Increased conservation hatchery programs • Decreased mitigation hatchery programs (e.g., 50% reduction in production)
Hydropower	**Current Program** • Continue planned improvements • Existing flow augmentation levels • Existing funding levels	**Aggressive Program** • Additional flow and spill • More aggressive capital improvement program • Additional funding	**Breach Lower Snake River Dams** • Breach four Snake River Dams • Additional funding

4.2.2 Alternative B
Harvest Constraints

Habitat – Option 1
Coordinate and Prioritize Federal Actions

Harvest – Option 3
Conservation Fishery Levels

Hatcheries – Option 3
Increase Conservation Programs and Significantly Decrease Mitigation Programs

Hydropower – Option 1
Current Program

Under Alternative B, the Snake River dams are not breached and the region relies instead on harvest constraints to recover fish runs, along with existing improvements in the hydropower system and improvements on federal habitat. All fisheries are held to conservation levels for a period of time (e.g., 10 years) to "jump start" recovery. Since fisheries are so constrained, it is logical to also reduce the production of mitigation hatchery fish. This reduction may provide further unquantifiable survival benefits to wild fish.

4.2.3 Alternative C
Aggressive Non-Breach

Habitat – Option 2
Coordinated Regional Plans

Harvest – Option 2
Fixed In-river Harvest Rates (1999 levels)

Hatcheries – Option 2
Increase Conservation Programs

Hydropower – Option 2
Aggressive Program

Alternative C defers a decision on dam-breaching and allows an interim period to determine whether aggressive action in all of the Hs (short of breaching) is likely to recover Snake River fish, and to resolve key scientific uncertainties. Hydropower actions include increased flows (especially in the Snake River) and increased spill. State and local governments contribute significantly to habitat protection (improved instream flows and water management; irrigation improvements; riparian protections, etc.) through state regulatory and voluntary programs. Additional populations are brought into hatchery conservation programs if necessary to prevent extinctions. Harvest is held at a flat rate based on 1999 fishing rates until stocks recover.

4.2.4 Alternative D
Maximum Protections

Habitat – Option 2
Coordinate Regional Plans with a default to Option 3 if increased states' and local efforts do not occur.

Harvest – Option 3
Conservation Fishery Levels

Hatcheries – Option 3
Increase Conservation Programs and Significantly Decrease Mitigation Programs

Hydropower – Option 3
Breach Lower Snake River Dams

Alternative D is the most aggressive scenario, in which all Hs make dramatic contributions in an effort to recover listed stocks throughout the basin. The most risk-averse option within each H is pursued to maximize efforts to rebuild stocks and improve productivity. In the case of hatcheries, conservation programs would increase outside of the Snake River, and mitigation programs would be reduced basinwide.

4.3 Implementation Issues for Integrated Alternatives

4.3.1 Implementation of Alternatives

This draft paper addresses implementation issues specific to the area of focus – habitat, hatcheries, harvest and hydropower. There are, however, broader issues related to implementation of the options ultimately selected in the final paper that cross all sectors. The following discussion on implementation is focused on these broader, crosscutting issues which are raised for regional discussion and comment.

Each federal agency participating in the development of the paper is cognizant of the well-founded criticism that federal funding and decision-making on fish and wildlife programs in the Pacific Northwest are not well coordinated. This lack of coordination results in Balkanized decision making and lost opportunities to maximize the effectiveness of federal funding. The federal agencies are seeking regional input on the alternatives described below as they consider what degree of coordination for both decisionmaking and funding they should strive for in the future.

Current Level of Coordination

There are numerous separate decisionmaking forums that guide the policy, funding, and implementation of actions in each of the Hs. While some coordination occurs among these forums, it is not consistent. Decisions are generally made without regard to their impact on activities in other forums or their possibilities to maximize potential benefits.

Hydropower operations are largely guided by NMFS' Regional Forum process. Through this process federal, state, tribal and nongovernmental representatives advise on implementation of the Biological Opinions issued by NMFS and the USFWS on the operation of the Federal Columbia River Power System. Hydropower operations are also addressed by the NPPC in its Fish and Wildlife Program pursuant to its authorities under the Pacific Northwest Electric Power Planning and Conservation Act.

Hatchery operations are guided by a number of entities, primarily state fish and wildlife agencies and the USFWS. In the *U.S. v. Oregon* litigation the court has retained continuing jurisdiction to equitably apportion harvest in the Columbia River between tribal and nontribal fisheries and address production from the hatcheries that support the fisheries. The NPPC also has a significant role in guiding the funding and operation of the hatcheries encompassed in its Fish and Wildlife Program.

Harvest is decided in several forums. Under the Magnuson-Stevens Act, ocean fisheries in federal waters off the coasts of Alaska, Washington, and Oregon are set by the North Pacific Fisheries Management Council and the Pacific Fisheries Management Council. Ocean fisheries are also regulated by agreements between the United States and Canada under the U.S.-Canada Pacific Salmon Treaty of 1985. Harvest in the Columbia River is decided in the court-overseen process of *U.S. v. Oregon*.

Habitat policy, funding and implementation are even more diffuse than the other Hs. Habitat policy on federal lands west of the Cascade Mountains, is generally guided by the Northwest Forest Plan. East of the Cascades, the policies of federal land and water management agencies, including the USFS, and BLM, govern federal land management. The Interior Columbia Basin Management process is expected to integrate management of these lands on a landscape scale. State, local, and tribal policies and regulations guide habitat policy on nonfederal lands, and the USBR programs influence nonfederal water use. The NPPC's Fish and Wildlife Program addresses habitat on private lands. Some federal policies and regulations, such as the Clean Water Act, also apply on private lands.

This draft paper describes in detail these decision-making forums and makes suggestions for improvements in their operation. One alternative for consideration in this draft is to continue to conduct implementation of the region's fish and wildlife programs through the current forums and at the current level of coordination. In other words, coordination would occur inconsistently.

Federal Coordination

One way to provide better coordination of federal fish and wildlife programs in the Columbia Basin is for federal agencies to develop a common set of priorities for funding and to coordinate decision making on implementation actions within each H. While federal agencies' programs are generally guided by Congressional authorizations and funded by federal appropriations, improved coordination of federal decision-making and funding is feasible. One example of coordinated funding and decision making is the BPA Fish Budget Memorandum Of Agreement (MOA). Under this 1996 MOA, the Army Corps of Engineers, the USBR, and BPA coordinate development of budgets for implementing the Biological

Opinions issued by NMFS and the USFWS on the operation of the Federal Columbia River Power System. In addition, BPA coordinates its implementation of the Northwest Power Planning Council's Fish and Wildlife Program through the regional prioritization process memorialized in the MOA.

Another alternative is for the federal agencies regulating and implementing fish and wildlife programs in the Columbia Basin to commit to coordinate the decision making and funding of their programs through a single entity. This level of coordination would require the federal agencies to agree on a common set of priorities and to coordinate their planning, funding and implementation actions. An example of this type of structure is a key component of the Northwest Forest Plan, which established a regional federal executive forum and thirteen provincial committees for obtaining advice from federal agencies, states, tribes, counties and other affected parties on federal forest management policies within the range of the Northern spotted owl.

However, the scope of coordination required in the Columbia River Basin is much broader than that of the Northwest Forest Plan since it encompasses decision-making and funding actions by federal agencies in each of the Hs in the Columbia Basin, not just land management west of the Cascades.

Coordination of Federal Agencies with States, Local Governments and Tribes

Coordination of federal decisionmaking and funding with that of states, local governments and tribes is another need.

The Columbia Basin Forum is a collaborative policy forum through which 13 Northwest tribes, the states of Oregon, Washington, Idaho and Montana, and the federal government operating through the regional federal agencies are planning to coordinate their decisionmaking on fish and wildlife issues in the Columbia Basin. Could the scope of their responsibilities be expanded to encompass coordination of implementation of a regional fish and wildlife program for states, tribes, local governments, and the federal agencies?

Another possible structure to host a larger coordination of federal, state, local and tribal programs is the NPPC. The scope of NPPC review is its fish and wildlife direct program, which constitutes programs across the Hs funded by BPA. In addition, in the last few years, Congress has asked the NPPC to review the programs of the Corps, the USBR, and the USFWS that BPA either funds directly or for which it provides reimbursement to the U.S. Treasury. In this process, the NPPC does not make final funding determinations, but makes final recommendations to funded entities, with the benefit of extensive input from fish and wildlife managers, independent scientists, and public comment. The NPPC might be used as a coordination forum for Columbia Basin fish and wildlife program implementation for the federal agencies as well as provide broader regional coordination through its established processes to seek input from tribes, states, local governments and regional stakeholders.

We invite comments on the feasibility and advisability of each of the alternatives described above and suggestions on the forum through which such coordination could occur.

5. Science Issues

A well-designed monitoring and evaluation program is a critical component of any conservation or restoration activity, and can play several roles within recovery planning. First, monitoring of specific projects is vital to determine whether those specific management actions have been effective. Second, large-scale monitoring and evaluation is important to assess the success of integrated actions (or recovery plans) in achieving desired population size, distribution and trends. Finally, well-coordinated management actions, when coupled with relevant monitoring and evaluation programs, can reduce uncertainty about the effect of those actions on salmon productivity. However, in order for monitoring efforts to be effective, they must have clearly defined objectives, and they must be designed to detect responses at the proper scale, both in space and in time.

Effective monitoring programs, like all scientific endeavors, must be well designed to be able to detect significant biological or physical change. Clearly defined questions, adequate controls and replication as well as appropriate sampling techniques must be included in a monitoring plan. Equally important, however, in designing monitoring programs, is the issue of scale. The scale (e.g., basin, subbasin, watershed or reach) at which a response is sought is critical for two reasons. Fish populations may respond to patterns seen at a different scale than that at which many management actions are implemented. For instance, riparian management actions typically affect a single reach. However, fish communities or populations may respond to the combination of riparian conditions seen across a watershed. Second, many management actions, by altering the system's susceptibility to floods, fire, mass wasting, or other natural disturbance events, affect the natural system at larger scales than that at which the action is implemented. For these reasons, a monitoring program should assess responses to management actions at multiple geographic and temporal scales.

At large scales (subbasin or watershed), population-level measures for fish, and landscape level attributes for management actions should be monitored. For fish, this would include abundance and distribution information; other important measures might include reproductive success and juvenile survival. Landscape-level attributes will vary by the management action or pattern being monitored. For instance, habitat monitoring efforts could include such measures as land-use patterns, the distribution of water-quality limited streams, or the frequency and location of landslides. Monitoring of hatchery actions would include the quality and abundance of released fish across the basin, as well as the distribution, migration patterns and spawning success of those fish. These types of data will serve several purposes. They will allow researchers to identify the response of fish populations to patterns of management actions and to larger-scale, indirect effects of those actions. They will also be a critical component of assessing the effect of actions integrated across the Hs (or recovery plans). Finally, these types of efforts, conducted across several subbasins over time, will play an important role as environmental or background monitoring. Widespread survey efforts will provide important baseline information, since changes in conditions outside the areas directly affected by a recovery plan or management action could mask the benefit (or lack of benefit) provided by those actions.

In addition to these large-scale measures, action-specific monitoring should also be implemented. Such monitoring would serve two purposes. First, it would ensure that necessary actions are being completed. Second, it would, when possible, determine whether discrete, anticipated responses are achieved. (Management actions implemented to achieve specific changes at particular life stages, such as passage improvements in the hydrosystem, lend themselves especially well to this type of monitoring.) These monitoring programs must not only be well designed experimentally, but also address appropriate life stages.

Management actions, when combined with monitoring programs at both scales, can also be used as experiments to address critical areas of uncertainty. Site-specific monitoring can provide insight into the physical mechanisms underlying population responses. This mechanistic information, coupled with management "experiments" across the landscape and a widespread survey effort has tremendous potential to increase our understanding of factors affecting fish populations. A wide variety of habitat and hatchery actions would lend themselves to this type of coordinated effort, as would some actions affecting fish harvest and conditions in the hydropower corridor.

Monitoring efforts are vital to ensure that recovery efforts are successful and have tremendous potential to increase our understanding of factors affecting salmon populations. Because of this importance, in March 2000, the Northwest Fisheries Science Center will convene a panel of academic and multi-agency scientists at the National Science Foundation's National Center for Ecological Analysis and Synthesis to consider both the types of questions best addressed through experimental management and the more technical issues of scale and sampling.

6. Glossary and Acronyms

Acronyms

A-FISH	Anadromous Fish Appendix
APR	Artificial Production Review
BA	Biological Assessment
BGS	Behavioral Guidance System
BIA	Bureau of Indian Affairs, U.S. Department of Interior
BLM	Bureau of Land Management, U.S. Department of Interior
BMP	Best Management Practices
BO	Biological Opinion
BPA	Bonneville Power Administration
CCBF	Conservation of Columbia Basin Fish
CBFWA	Columbia Basin Fish and Wildlife Authority
CREP	Conservation Reserve Enhancement Program
CRFMP	Columbia River Fish Management Plan
COE	Corps of Engineers
CRI	Cumulative Risk Initiative
CRISP	Columbia River Salmon Passage (Model)
CRITFC	Columbia River Inter-Tribal Fish Commission
CWT	Coded Wire Tag
D	Differential Delayed Transport Mortality
DOI	U.S. Department of Interior
DREW	Drawdown Regional Economic Workgroup
EDT	Ecosystem Diagnosis and Treatment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
ESBS	Extended Length Submersible Barrier Screen
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FEMAT	Forest Ecosystem Management Assessment Team
FERC	Federal Energy Regulatory Commission
FGE	Fish Guidance Efficiency
FSA	Farm Services Administration
FOTG	Fish Operations Technical Group
FPE	Fish Passage Efficiency
FWP	Columbia River Basin Fish and Wildlife Program
HCP	Habitat Conservation Plan
HUC	Hydrologic Unit Code
HMU	Habitat Management Units
H-VSP	Habitat conditions to support viable salmon populations
ICBEMP	Interior Columbia Basin Ecosystem Management Project
IHOT	Integrated Hatchery Operations Team
INFISH	USFS interim strategies for managing fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of Nevada.
IPCo	Idaho Power Company
IRC	Integrated Rule Curve
ISAB	Independent Scientific Advisory Board
ISG	Independent Scientific Group (formerly Scientific Review Group)
ISRP	Independent Science Review Panel
JBS	Juvenile Bypass System
Kcfs	1000 cubic feet per second
LSRFS	Lower Snake River Feasibility Study
MOA	Memorandum of Agreement
MPI	Matrix of Pathways and Indicators
M&E	Monitoring and Evaluation
NATURES	Natural Rearing Strategies
NMFS	National Marine Fisheries Service
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
NRC	National Research Council

NRCS	Natural Resources Conservation Service
PAC	Provincial Advisory Council
PACFISH	USFS and BLM interim strategies for managing anadromous fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of California.
PATH	Plan for Analyzing and Testing Hypotheses
PFC	Properly Functioning (Habitat) Conditions
PFMC	Pacific Fisheries Management Council
PIT	Passive Induced Transponder
PST	Pacific Salmon Treaty
PUD	Public Utility District
QAR	Quantitative Analysis Report
RAC	Regional Advisory Council
ROD	Record of Decision
RPA	Reasonable and Prudent Alternatives
SASSI	Salmon and Steelhead Stock Inventory
SAR	Smolt-to-Adult Return
SBC	Surface Bypass and Collection
SIMPAS2	NMFS Spreadsheet Model
SOR	System Operation Review
SPS	Significant Population Segment
SRBA	Snake River Basin Adjudication
STS	Submersible Traveling Screen
TMDL	Total Maximum Daily Load
TSP	Turbine Survival Program
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
USFS	U.S. Forest Service
USFWS	United States Fish and Wildlife Service
VAR Q	Variable Q
VBS	Vertical Barrier Screen
VSP	Viable Salmonid Population
WDF	Washington Department of Fisheries
WSC	Watershed Council

Technical Terms

Adaptive management - Feedback based on knowledge or data generated by monitoring and evaluation actions, of the effects or results of an implemented action. The information and data are purposefully collected and used improve future management plans and actions.

Adfluvial - Possessing a life history trait of migrating between lakes or rivers and streams.

Adult fallback - Adult salmonids that swim or drift back downstream through the powerhouse or spillway of a dam after passing upstream of the facilities and must pass the dam a second time in order to successfully complete their migration.

Alevin - The developmental life stage of young salmonids and trout that are between the egg and fry stage. The alevin has not absorbed its yolk sac and has not emerged from the spawning gravels.

Allocation percentage - Division of the fish resource among harvesters and needs for reproduction.

Anadromous Fish - Fish that hatch and rear in fresh water, migrate to the ocean (salt water) to grow and mature, and migrate back to fresh water to spawn and reproduce.

Artificial production - Spawning, incubating, hatching or rearing fish in a hatchery or other facility constructed for fish production.

Artificial Production Review (APR) - The Northwest Power Planning document that recommends how to use of fish hatcheries in the Columbia River Basin.

Artificial propagation - Any assistance provided by man in the reproduction of Pacific salmon. This assistance includes, but is not limited to, spawning and rearing in hatcheries, stock transfers, creation of spawning habitat, egg bank programs, captive broodstock programs, and cryopreservation of gametes.

Artificial selection - Assistance provided by man in the determination and selection of the **genetic fitness** of an individual of a species for artificial fish production.

At-risk Fish Stocks - Stocks of anadromous salmon and trout that have been identified by professional societies, fish management agencies, and in the scientific literature as being in need of special management consideration because of low or declining populations.

At-risk Populations - Fish, wildlife, and plant populations that have been identified by professional societies, fish management agencies, and in the scientific literature as being in need of special management consideration because of low or declining populations.

Augmentation - The practice of rearing and releasing artificially propagated salmon and steelhead to enhance natural population levels.

Augmentation (of stream flow) - Increasing stream flow under normal conditions, by releasing storage water from reservoirs.

Authorities (tribal government) - The right and power which an officer has in the exercise of a public function to compel obedience to his lawful commands.

Bank configuration – The contour and the functional arrangement of the vegetative and soil materials that form and delimit the stream channel from the surrounding land.

Bank integrity - This generally refers to the structural integrity of a bank or how well a particular bank resists erosion.

Base stream flow(s) - The flow resulting precipitation that percolates to the ground water and slowly moves through the substrate to a channel. In contrast, stormflow is precipitation that reached the channel over a short time frame by surface or underground routes.

Biological Community - A naturally occurring, distinctive group of different organisms which inhabit a common environment, interact with each other, and are relatively independent of other groups.

Biological Potential - The ability for depressed stocks of fish to experience production levels consistent with its available habitat and within the natural variations in survival for the stock.

Broodstock, captive breeding - Adult fish maintained in captivity, used to propagate the subsequent generation of hatchery fish.

Broodstock, wild - Adult fish harvested from indigenous populations used to propagate the subsequent generation of hatchery fish.

Bypass systems - Juvenile salmonid bypass systems consist of screens lowered into turbine intakes to divert fish away from turbines at hydroelectric dams. Bypassed fish are either returned directly to the river below the dam or into barges and trucks for transport to a release site downstream from Bonneville Dam. PIT-tag detectors identify all PIT-tagged fish passing through the bypass systems. In addition, the systems are equipped with subsampling capabilities that allow hands-on enumeration and examination of a portion of the collection for coded-wire tags (CWT), brands, species composition, injuries, etc. Recovery information at bypass systems is used to develop survival estimates, travel time estimates, and run timing; to identify problem areas within the bypass system; and as part of the basis for flow management decisions during the juvenile migrations.

Capacity (landscape) – The upper limit in the number of organisms that an environment can support due to finite amounts of space, food, and other needed resources. Capacity regulates population responses that are dependent of the density of organisms (MB).

Captive-breeding program - A form of artificial propagation involving the collection of individuals (or gametes) from a natural population and the rearing of these individuals to maturity in captivity. For listed species, a captive broodstock is considered part of the evolutionarily significant unit (ESU) from which it is taken.

Carrying Capacity - The maximum number and type of species which a particular habitat or environment can support without detrimental effects.

Channel complexity - The number of physical features (e.g. pool-riffle ratios, size and classes of substrate particles, amount and type of woody debris, cannel slope, shape, sinuosity, and pattern) contained in a channel. The greater the number of features found in a given length (e.g. two meander lengths) the greater the complexity.

Channel modification - Any change, natural or induced, in the character of a channel.

Channel simplification - Reducing channel complexity by any natural or induced means.

Channel widening - Increasing the width of a channel by natural or induced means.

Cobble (nests) - Substrate particles that range from 2 to 10 inches in diameter at its largest ordinate.

Cohort - Individuals all resulting from the same birth-pulse, and thus all of the same age.

Compliance (monitoring) - Adhering to the protocols of a monitoring and evaluation plan.

Configuration (FCRPS) - Significant structural components or facilities of the FCRPS (also see FCRPS).

Conservation Crisis Levels - Conservation crisis levels are defined as levels similar to the 1999 harvest rates for listed spring/summer chinook (5 to 7 percent), and comparable conservation crisis levels for listed Snake River fall chinook and listed steelhead.

Conservation easement - Acquiring, through lease, purchase, or donation, the right to protect, improve, or maintain habitats or a particular habitat conditions.

Conservation hatchery program - A program that uses artificial propagation to recover Pacific salmon by maintaining the listed species' genetic and ecological integrity

Conservation Status - The relative health of a salmonid population, in particular whether it warrants listing as threatened or endangered under the Endangered Species Act.

Conservation Strategy - A management plan for a species, group of species, or ecosystem that prescribes standards and guidelines that if implemented provide a high likelihood that the species, groups of species, or ecosystem, with its full complement of species and processes, will continue to exist well-distributed throughout a planning area, i.e., a viable population.

Cost-share projects - Projects that are funded by two or more different agencies, groups, or individuals.

Critical habitat - The geographic area occupied by or essential to the species.

Critical (stock) - A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Cumulative Risk Initiative (CRI) - Scientific analysis developed by the Northwest Fisheries Science Center of NMFS, to model quasi-extinction projections for salmon and steelhead ESUs. The CRI also examines where in the salmon life cycle opportunities exist to improve survivals and reduce the risk of extinction.

Declining (stock) - A stock experiencing a decline in production levels.

Default Indicator Criteria - indicators of ecosystem condition that are to be used until they are replace with more accurate criteria based on a more site specific analysis. The indicator criteria has been provided to describe the conditions in upland, riparian, and instream areas that function to maintain productive populations of salmonids (NMFS). Also see: properly functioning conditions (below).

Degradation - This term typically refers to the loss or reduction in one or more characteristics of an environment. It may be as simple as the changes due to erosion or as complex as the loss or reduction of one or more ecosystem functions.

Delisting - Removal of a species or ESU from endangered or threatened status under the ESA.

Density-dependence - A process, such as fecundity, whose value depends on the number of animals in the population per unit area.

Depressed (stock) - The report "1992 Washington State Salmon and Steelhead Stock Inventory" (WDF et al., 1993) defines "depressed" as a stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.

Descaling - Physical injury to a fish that results in the removal of scales and protective mucus layers.

Dewatering - Removing all the water from an artificial or natural container or channel. Typically refers to the immediate downstream habitat effects associated with a water withdrawal action that diverts the entire flow of a stream or river to another location.

Discharge (into estuary) – The quantity or rate of water entering the Columbia River estuary.

Dissolved gas - The amount of a particular gas or of all gasses dissolved in water. Usually measured in parts per million.

Dissolved oxygen (DO) - The amount of oxygen that is dissolved in particular volume of water. The amount of DO can be an important indicator of the condition of a water body.

Diversion structures - Typically refers to structures that diverts of withdraws water from a stream or river to another location usually for irrigation purposes.

Domestication - The intentional or unintentional process by which wild plant and animals adapted to cultivation, tamed, or loses its ability to survive in the wild.

Drafting (reservoir) - Lowering of the elevation of a reservoir, which would include passing both in-flow and stored water.

Dredge and fill (permits) - Permits required by Section 404 of the Clean Water Act to remove substrate material from a water body or to place or disposed of any material (sand, gravel, rocks, pilings etc.) in a body of water.

Ecosystem - The biotic and abiotic characteristics of given area. An ecosystem can be as small as a wetland or as large as a biome (e.g. Great Basin Shrub-steppe Deserts, Tropical Rain Forests of the Lower Amazon Basin, The Columbia River Estuary). They are typically defined by some major habitat characteristic. Each has a unique set of physical, chemical, and climatic characteristics to which the plant and animal life have adapted.

Ecosystem Diagnosis and Treatment (EDT) - An expert opinion and empirical modeling approach to stream and watershed assessments.

Egg Incubation - Egg development of the embryo, influenced by temperature and other environmental factors.

Emergence - The process during which fry leave their gravel spawning nest and enter the water column.

Emigration - Referring to the movement of organisms out of an area.

Endangered (ESA) - A species of plant or animal in danger of extinction throughout all or a significant portion of its range.

Endangered Species Act (ESA) - An act passed by Congress in 1973 intended to protect species and subspecies of plants and animals that are of "aesthetic, ecological, educational, historical, recreational and scientific value." It may also protect the listed species' "critical habitat", the geographic area occupied by or essential to the species. The U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) share authority to list endangered species, determine critical habitat and develop recovery plans for listed species.

Endemic (species) - Native to or limited to a specific region.

Environmental baseline condition - This is some pre-project environmental condition. It is the environmental standard that project effects are measured against.

Escapement - The number of salmon and steelhead that return to a specified measuring location after all natural mortality and harvest have occurred. Spawning escapement consist of those fish that survive to spawn.

Estuary, estuarine - The area where the fresh water of a river meets and mixes with the salt water of the ocean.

ESU (evolutionary significant unit) - A salmon population or group of populations that are substantially reproductively isolated from other conspecific population units, and contributes substantially to ecological/genetic diversity of the biological species as a whole.

Evolutionary response - The adaptations of a species accrued in response to environmental changes over a long period of time.

Exploitation rate - The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly basis). For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate would be 0.72.

Extant (populations) - describes types or species of animals that are currently living. Not extinct.

Extinction risk - A component to modeling scenarios involving stocks becoming extinct.

Extirpate - To destroy or remove completely, as a species from a particular area, region, or habitat.

Extra Mortality - Numerous suites of conditions corresponding to a deteriorating situation for the listed species, crucial to the assessment of how well different management options will perform.

Fecundity - The total number of eggs produced by a female fish.

Fisheries (in-river) - Harvest occurring within freshwater areas.

Fisheries (known-stock) – Harvest targeting a specific stock(s).

Fisheries (marine or ocean) - Harvest occurring in marine areas.

Fishery (Indian) - See "Tribal Fishing Rights."

Fishery (non-Indian) - Fisheries conducted by nontribal members.

Fishery (mixed-stock) - Harvest occurring at such a time or location as to potentially catch fish from multiple stock(s).

Fishery (subsistence) - See "Tribal Fishing Rights."

Fishery, ceremonial - See "Tribal Fishing Rights."

Fishing pressure - The impact of fishing on fish populations.

Flood plains - The area along a stream or river that is subject to flooding.

Flow Augmentation - Increasing river flows during the juvenile out-migration by reducing winter drafts at FCRPS storage reservoirs to provide higher spring flows and a higher probability of reservoir refill; by drafting reservoirs during the out-migration season (April through August); and by acquisition of water from nonfederal sources.

Flow Requirements - Quantity of flow for a given stream reach necessary for fish survival. These requirements may vary by species and life stage.

Flow timing – A water release schedule associated with hydropower facilities or natural flow regime or hydrograph.

Fluvial – Of or pertaining to a river or stream. This includes the slope, shape, and channel, its substrate characteristics, its flow characteristics, its sediment transport characteristics and geomorphic conditions that contribute to these conditions.

Fry (emergence) - The first free-swimming life stage of a salmonid.

Gas Bubble Disease - Conditions caused when dissolved gas in supersaturated water comes out of solution and equilibrates with atmospheric conditions, forming bubbles within the tissues of aquatic organisms. This condition can kill or harm fish.

Gas Supersaturation - The overabundance of gases in turbulent water, such as at the base of a dam spillway. Can cause fatal condition in fish similar to the bends.

Geneflow - The incorporation of migrant genes into a receiving population.

Genetic Diversity - The array of genetic traits that exists within a population, due to a large number of slightly dissimilar ancestors, which enables it to adapt to changing conditions.

Genetic Exchange - The transfer of genes among individual organisms within a population.

Genetic Fitness - The relative reproductive success of a population (genotype) as measured by fecundity, survival, and other life history parameters.

Genetic Interactions - Outbreeding between genetically differentiated populations. Straying of genetically divergent hatchery produced salmon into a native population.

Genetic Variability - Differences in the frequency of genes and traits among individual organisms within a population.

Geographically Localized (populations, stocks) - Populations restricted to a well defined area set by systems and processes involved in the world's weather, mountains, seas, lakes, etc.

Habitat complexity - The extent and variety of water, soil, geomorphic features and plant species of a given area. The more features the more complex a habitat.

Habitat condition indicator - Some standard (e.g. one pool and one riffle per meander length of a river) that is used to index the suitability of a habitat for some species (e.g. trout).

Habitat conservation planning - Plans to protect, improve, or maintain the status or condition of a given habitat.

Habitat diversity - The number and

distribution of physical, chemical and typically plant material in an area. The greater the number of features, the greater the diversity.

Harvest (flat rate) – Harvest occurring at a fixed rate.

Harvest (in-river schedule) - Designated harvest dates and times for in-river fisheries.

Harvest (selective) - Harvest targeted to specific fish or fish runs.

Harvest (sustainable) - A degree of fish harvest that does not deplete fish populations below replacement levels.

Harvest (tribal allocation) - See "Tribal Fishing Rights."

Harvest (tribal) - See "Tribal Fishing Rights."

Harvest management - The process of setting regulations for the commercial, recreational and tribal fish harvest to achieve a specified goal within the fishery.

Harvest pressures - The degree and manner in which harvest efforts (commercial, recreational, and tribal) affect fish populations.

Harvest rate - The proportion of a returning run or total population of salmonids that is taken by fisheries, usually expressed as a catch to escapement ratio.

Harvest selectivity - A harvest strategy that targets a specific species.

Hatchery – A facility where fish are collected, spawned, reared, and (typically) released (see Artificial propagation).

Hatchery and Genetic Management Plan (HGMP) - A document detailing the continued operation of an artificial propagation program.

Hatchery intervention – The use of artificial propagation to enhance, conserve, and recover salmonid populations.

Hatchery release - Artificially propagated fish released into the wild for the purpose of mitigating, supplementing, augmenting, and restoring a fish population or a fishery.

Healthy (stock) - A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Heavy metals - Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Homing - The ability of a salmon or steelhead to correctly identify and return to their natal stream, following maturation at sea.

Hydraulics - The principles governing mechanical properties of static and moving water (provisions of optimum passage at dams depend on knowledge of fish behavioral response to hydraulics at dams).

Hydroacoustics - The use of sound to estimate the number of fish using a specific passage route.

Hydrograph (river) - A graphic representation of stage, flow, velocity, or other characteristics of water at any given point.

Hydrologic function - The effects of water on the earth's surface, soil and rocks.

Hydropower – Electrical power generation produced by dams.

Impoundment – Any human-made structure for retaining natural flows (e.g., reservoirs).

Inbreeding – The mating of related individuals.

Indigenous - Existing, growing, or produced naturally in a region.

Infrastructure - An underlying base or foundation.

Institutional barrier - Impediment or obstruction to achieving institutional goals based on current policies and mandates enacted by other institutions.

Instream flows - The amount of water passing a particular point in a stream or river, usually expressed in cubic-feet per second (cfs). Typically concerned with the minimum flow in a stream needed to protect and maintain aquatic life.

Integrated Rule Curves (IRC) - A set of reservoir operating criteria designed to meet multiple objectives (e.g. flood control, irrigation, recreation, and fish habitat.)

Inter-tidal (marsh) - Marshes located in the zone (usually in an estuary) between mean high tide and mean low tide.

Juvenile Bypass Outfall - The structure and location of the juvenile bypass system discharge.

Lacustrine - Of or pertaining to a lake (e.g. a lake ecosystem)

Landscape-level characteristics - Those characteristics associated with a heterogeneous land area with interacting ecosystems.

Life history strategies/types – Traits and characteristics of a stock that reflect adaptations to a unique environment (e.g., spawn timing).

Life stage - An organisms period of development to adulthood.

Listed fish, species - Species determined to be threatened (any species in danger of becoming endangered in the foreseeable future) or endangered (a species in danger of extinction throughout all or a significant portion of it's range) as allowed under the ESA.

Local adaptations – Specialized characteristics or traits expressed by geographically distinct populations.

Low-gradient (tributary habitats) - a stream or river with a slope of less than 0.02 percent.

Mainstem - The principle channel of a drainage system into which other smaller streams or rivers flow (SN).

Management prescription – The management practices and intensity selected and scheduled for application to a specific area. (FEMAT)

Mark-selective fisheries - A fishery managed to selectively harvest distinctively marked fish.

Mechanical bypass system – See "bypass system."

Metapopulation - A population comprising local populations that are linked by migrants, allowing for recolonization of unoccupied habitat patches after local extinction events.

Migrant blockages – Any of a number of obstructions that prevent movement of fishes up- and down stream.

Minimum Gap Runners (MGR) - Turbine blades that maintain extremely close tolerance (less than 0.25 inches) between the bade, hub, and encasing draftube walls (discharge ring).

Mitigate - make less severe or more bearable,

Mitigation hatchery fish - Artificially produced fish that are propagated to compensate for loss or reduction of a specific fish population.

Morphology - The structure, form and appearance of an organism.

Multi-scale – A series of graduated spatial geographic areas or temporal periods.

Multi-Species Framework Project – a collaborative project of the Northwest Power Planning Council, the Columbia River Basin's Indian Tribes and the United State Government to create a handful of scientifically based, agreed upon alternatives for determining how best to achieve fish and wildlife recovery in the Columbia River Basin.

Natal (stream) - Stream of birth.

Natural fish - A fish that is produced by parents spawning in a stream or lake bed, as opposed to a controlled environment such as a hatchery.

Natural regenerative processes – Restoration of ecosystem condition based on a series of related physical or biological activities existing in nature.

Naturally spawning fish/populations - Populations of fish that have completed their entire life cycle in the natural environment without human intervention.

Non-endemic stocks - Not native to or limited to a specific region.

Non-indigenous stocks - Not existing naturally in a region, state, country, etc.

Non-point source pollution (program) – Section 319 of the Clean Water Act establishes a Nonpoint Sources Management program. States, Territories, and Indian Tribes receive grant money which supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, and monitoring to assess the success of specific nonpoint source implementation projects.

Nutrient cycling - Circulation or exchange of elements such as nitrogen and carbon between nonliving and living portions of the environment. (SN)

Off-channel (areas) – Any relatively calm portion of a stream outside of the main flow. (SN)

Off-Channel Water Storage Capacity - Water storage in areas outside the mainstem

Columbia.

Operations (FCRPS) - Management of the FCRPS projects as set forth in the 1995 FCRPS and 1998 Steelhead Supplemental Biological Opinions. Along with establishing certain hard constraints at storage reservoirs, the biological opinions established the Regional Forum, which as one of its responsibilities has some flexibility to recommend real-time (i.e. in season) management decision for flow augmentation, spill, and transportation decisions in order to best achieve passage strategies for migrating salmon.

Outbreeding - The interbreeding of distantly related or unrelated individuals.

Outbreeding depression - The loss of local adaptations as a result of interbreeding wild and hatchery fish.

Out-of-stream water use – Any use of stream water that occurs outside the stream channel, such as irrigation.

Pacific Salmon Treaty (PST) - A long-term and comprehensive management plan, negotiated between the United States and Canada, that would govern salmon fisheries in Southeast Alaska, British Columbia, and the Pacific Northwest.

Passive integrated transponder (PIT) tagging - Passive Integrated Transponder tags are used for identifying individual salmon for monitoring and research purposes. This miniaturized tag consists of an integrated microchip that is programmed to include specific fish information. The tag is inserted into the body cavity of the fish and decoded at selected monitoring sites.

Performance measures - Define the contribution that is needed at each life-history stage to achieve the overall biological goals and objectives, and which do so in context with the contributions from other life stages.

Performance-based management - Measures or actions that seek to reach established recovery objectives, and which can be adjusted over time in response to their degree of success in achieving those objectives.

pH - The negative logarithm of the molar concentration of hydrogen ion. It refers more simply to the acidity of a solution.

Plan for Analyzing and Testing Hypotheses (PATH) - The PATH process is a multi-agency/multi-participant effort to allow a wide community of scientists and managers to analyze hypotheses for salmon decline and examine the outcome of different management options, including drawdown and transportation.

Plume – A downstream or offshore conveyance of water and suspended sediments (e.g., the Columbia River plume extends miles into the Pacific Ocean).

Point source discharges - Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types.

Polluted – (1) An area that has been contaminated, especially by a waste material that contaminates air, soil, or water. (2) Any solute or cause of change in physical properties that renders water unfit for a given use.

Population(s) - A group of individuals of the same species occupying a defined locality during a given time that exhibit reproductive continuity from generation to generation.

Population dynamic - The aggregate of changes that occur during the life of a population.

Population identification - The process of determining that a set of individuals belong in a population grouping.

Productive capacity - The capacity of a water body or production facility to produce fish.

Progeny - Offspring.

Properly functioning conditions (PFC) – Properly functioning condition is the sustained presence of natural habitat-forming processes in a watershed (e.g., riparian community succession, bedload transport, precipitation runoff pattern, channel migration) that are necessary for the long-term survival of the species through the full range of environmental variation. PFC, then, constitutes the habitat component of a species' biological requirements (Also see: NMFS 1996).

Province – A large geographic area that has similar set of biophysical characteristics and processes due to effects of climate and geology. Provinces are roughly equal to groups of 4th field USGS hydrologic unit codes (averages 1,000,000 hectares).

Push-up dam – An instream water diversion created by pushing streambed or other material into a mound which diverts part of the stream flow out of the channel.

Ramping Rates - The rate of change of discharge from a project, often limited by a specified rate of downstream water surface elevation change.

Reach - A section of stream between two defined points.

Rear - To feed and grow in a natural or artificial environment.

Rebuilding flows – Process of returning water to a stream to approximate historic flow patterns.

Reclamation Project(s) - Projects constructed under the Reclamation Act and operated by the U.S. Bureau of Reclamation, which administers some parts of the federal program for water resource development and use in western states. The Bureau of Reclamation owns and operates a number of dams in the Columbia River Basin, including Grand Coulee Dam.

Recovery - Defined as the point at which a listed species has improved to such an extent that it no longer requires the protection of the ESA.

Recovery goal - The reestablishment of a threatened or endangered species to a self-sustaining level in its natural ecosystem (i.e., to the point where the protective measures of the Endangered Species Act are no longer necessary).

Recovery planning areas - Any geographic area that regulatory agency uses to set the boundaries of a regional recovery plan for salmon it is usually a river basin or subbasin.

Redd - A nest of fish eggs covered with gravel.

Refugia – Locations and habitats that support populations of organisms that are limited to small fragments of their previous geographic range (FEMAT).

Resident fish - Occupying headwater reaches; may disperse locally, but generally considered non-migratory.

Restoration – Reestablishment of pre-disturbance aquatic functions and related physical, chemical, and biological characteristics (NRC).

Riparian (zones) - Those terrestrial areas where the vegetation complex and microclimate conditions are products of the combined presence and influence of perennial and /or intermittent water, associated with high water tables, and soils that exhibit some wetness characteristics (FEMAT).

Riprap - Refers to rocks or concrete structures used to stabilize stream or riverbanks from erosion (SN).

River of origin - The river system in which a given salmonid was hatched (see natal stream).

Road treatments – Any of a number of restorative activities conducted to improve drainage, erosion, or stability of a road, such as, ripping and seeding the road surface, planting cut-slopes, removing the road from the landscape by reestablishing the original land contour.

Run (fish) - A group of fish of the same species that migrate together up a stream to spawn, usually associated with the seasons, e.g., fall, spring, summer, and winter runs. Members of a run interbreed, and may be genetically distinguishable from other individuals of the same species.

Run timing - The time of year that the fish return to their rivers of origin to spawn.

Runoff - Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.

Salinity concentrations - The concentration of salt in a body of water. The salinity of a saltwater wetland changes whenever freshwater is added when it rains, and each time the saltwater is added or removed when tide rises and falls.

Salmonids - Fish of the family Salmonidae, that includes salmon and steelhead.

Scientific protocols - A set of conventions governing data treatment and analysis procedures.

Scour of redds – Dig or remove gravels and eggs from redds by a powerful current of water.

Screens/ladders (fish) - Wire mesh screens placed at the point where water is diverted from a stream, river, and through a turbine at a dam to help keep fish from entering the diversion or passageway. Fish ladders are devices made up of a series of stepped pools, similar to a staircase, that enable adult fish to migrate upstream past dams.

Seasonal Flow Patterns – Natural changes and fluctuations in stream flows occurring over the course of a year.

Secure (habitat) – Reducing or eliminating problems caused by past human activities to prevent further degradation to remaining healthy areas (Doppelt et al. 1993).

Sediment regime(s) (input, storage, transport) - The distribution of sediment input, transport, and storage in a river system through time.

Segmented habitat – Habitat that is cutoff from other portions of the habitat. Refers to habitat wherein free movement of individuals from portion of the habitat to other portions is restricted.

Selective fishery strategy - A fishery management tool that allows selective retention of certain identifiable salmonid stocks (identified by marking, time, area, or gear methods) in order to minimize impacts on listed species.

Selective fishing gear - Fishing gear that, while targeting the intended species and size groups, allows non-target species to be released with little or no mortality.

Sensitive species - Those species that (1) have appeared in the Federal Register as proposed for classification and are under consideration for official listing as endangered or threatened species or (2) are on an official state list or (3) are recognized by the U.S. Forest Service or other management agency as needing special management to prevent their being placed on federal or state lists.

Sensitivity (population) - The susceptibility of a population to positive or negative inputs.

Sensitivity Analysis (PATH) - In addition to the uncertainties that are explicitly incorporated into the calculation of probabilities of meeting standards, the detailed results presented in the PATH FY98 Report also explored the effects of other assumptions on the overall results. They looked specifically at the sensitivity of results to the four factors: habitat, harvest, bird predation in the Columbia River estuary, and upstream survival rates. (Also see PATH.)

Sluiceway Outfall - The structure and location of the discharge of the surface dam outlet designed to collect and dispose of debris collected at the dam face.

Smolt - Refers to the salmonid or trout developmental life stage between parr and adult, when the juvenile is at least one year old and has adapted to the marine environment.

Smolt Travel Time - The time required for smolt transit a stream reach during downstream migration.

Smoltification - Refers to the physiological changes anadromous salmonids and trout undergo in freshwater while migrating toward saltwater that allow them to live in the ocean.

Spatial and temporal scales - The size/range of place and time used in modeling or data analysis.

Spawn - The act of reproduction of fishes. The mixing of the sperm of a male fish and the eggs of a female fish.

Spawning gravel – Streambed materials in which salmon lay their eggs, usually gravels free of fine sediments.

Species of concern - An unofficial status for a species whose abundance is at low levels.

Spill – Releasing water over a dam's spillways rather than channeling it through the powerhouse.

Spillway flow deflectors (flip lips) - Structures that limit the plunge depth of water over the dam spillway, producing a less forceful, more horizontal spill. These structures reduce the amount of dissolved gas trapped in the spilled water.

Stock - A specific population of fish. When referring to salmon, a specific population of fish spawning in a particular stream during a particular season.

Stock structure - The suite of characteristics (in particular genetic attributes) that distinguish one stock of salmonids from another.

Storage capacity - The active storage capacity (above the dead pool) of all the reservoirs in the Columbia Basin, including those in Canada.

Storage reservoirs - A reservoir primarily used to actively store and draft water. These reservoirs often have a large active storage capacity.

Stranding – Causing fish to be trapped in stream reaches due to insufficient water, especially as a result of water withdrawal.

Straying - A natural phenomena of adult spawners not returning to their natal stream, but entering and spawning in some other stream.

Stream segments – A portion of a stream channel.

Subbasin – A watershed area defined by 4th – field USGS hydrologic unit code the size averages 200,000 hectares.

Substrate - The composition of a streambed, including mineral and organic materials.

Subwatersheds - A watershed area defined by 6th field USGS hydrologic unit code the size ranges from 5 to 15,000 hectares.

Supplementation - Artificial propagation intended to reestablish a natural population or increase its abundance.

Surface Bypass Collection (SBC) - System designed to divert fish at the surface before they have to dive and encounter the existing turbine intake screens. SBC directs the juvenile fish into the forebay, where they are passed downstream either through the dam spillway or via the juvenile fish transportation system of barges and trucks.

Survivorship - A measure of survival tied to each of a species' life stages.

Take (legal/illegal) - Under the Endangered Species Act, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect an animal, or to attempt to engage in any such conduct.

Terminal area - rivers of origin.

Terminal fishery - Fisheries near freshwater (usually the mouth of rivers or bays or near a hatchery release site) where the targeted species is returning to spawn.

Threatened (ESA) - A genetic population that is at risk of becoming endangered in the foreseeable future.

TMDL – Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's source (EPA).

Transport (juvenile) - Collection and transport via barge and truck of out migrating juvenile salmonids from several FCRPS collection projects to a location downstream from Bonneville Dam, the lowermost dam on the Columbia River.

Trash Shear Boom - A floating device aligned with flow that allows floating debris to be guided to a specific removal point.

Tribal fishing rights - The guaranteed right for Native Americans to fish in their usual and accustomed Places. The right was established in a series of treaties dating from the mid-1850s and it applies to a number of tribes and their various harvesting practices (i.e., commercial and ceremonial and subsistence).

Tributary habitats - Fish habitat provided by a stream that flows into another stream, river, or lake.

Trust obligations/responsibility - Governmental obligations to the tribes under the treaties of 1855.

Turbidity – The cloudiness of water caused by suspended matter that interferes with the passage of light through the water or in which visual depth is restricted (SN).

Value-added commercial enterprises - Any business venture based on taking a product whether raw or partially processed, and processing it further to increase its value to the consumer.

Viability (population) - A population in a state that maintains its vigor and its potential for evolutionary change.

Viable Salmonid Population (VSP) - An independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction over a 100-year time frame.

Water conveyances – Devices used to transfer water from one location to another, usually from a natural water body to the land surface for irrigation, or for an industrial use. Examples include pipes, lined or unlined ditches, and irrigation canals.

Water quality limited - A water body that does not meet the federally approved state water quality standard establish under the provision of the Clean Water Act.

Water table elevation – The elevation at which groundwater will enter a well hole and attain a static level. Groundwater below this level is held in the intergranular pores on the soil or rock, or joints or fractures in the rock. Above the water table is a zone in which the pores of the soil or rock are completely filled with water held up by capillary tension. (DL).

Watershed - A watershed area defined by 5th – field USGS hydrologic unit code the size ranges between 20 to 40,000 hectares.

Watershed analysis – A systematic, science-based procedure for characterizing ecosystem conditions, and the state of ecosystem processes and functions.

Watershed assessment – (See watershed analysis). The term assessment rather than analysis often implies that a process with less scientific rigor was used.

Weak (stock) - Listed in the Integrated System Plan's list of stocks of high or highest concern; listed in the American Fisheries Society report as at high or moderate risk of extinction; or stocks the National Marine Fisheries Service has listed. "Weak stock" is an evolving concept; the Council does not purport to establish a fixed definition. Nor does the Council imply that any particular change in management is required because of this definition."

Wetland(s) – Areas that are inundated by surface water or groundwater with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that require saturated or seasonally saturated soil condition for growth and reproduction (Executive Order 1990). Examples of wetlands include swamps, marshes, and bogs (FEMAT).

Wild fish - See "natural fish."

Woody debris input – Refers to the processes that move woody vegetation from land areas to the stream environment. Examples of processes include landslides, debris flows, wind throw, and disease.

7. REFERENCES

Apperson, K.A. and P.J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1990. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-AI79-88BP93497. Project No. 88-65. Portland, Oregon 67 pp.

Bell, M.C. 1986. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Office of the Chief of Engineers, Fish Passage Development and Evaluation Program, Portland, Oregon.

Bevan, D., J. Harville, P. Bergman, T. Bjorn, J. Crutchfield, P. Klingeman, and J. Litchfield. 1994. Snake River recovery team: final recommendations to the National Marine Fisheries Service. National Marine Fisheries Service. Portland, Oregon.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in W.R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. American Fisheries Society, Bethesda, Maryland.

Bonneville Power Administration (BPA). 1993. *In*: U.S. Fish and Wildlife Service. Undated. White Sturgeon: Kootenai River Population *Acipenser transmontanus* draft recovery plan. 132 p.

Bonneville Power Administration and U.S. Bureau of Reclamation. 1993. Columbia River Basin, System Operational Review. Irrigation Depletion Estimate. September 10, 1993, prepared for Bonneville Power Administration by A.G. Crook Company.

Brannon, E.L., C.L. Melby, and S.D. Brewer. 1984. Columbia River white sturgeon enhancement. Final Report to Bonneville Power Administration. Contract No. DEAI79-84BP18952; Project No. 83-316. Portland, Oregon. 43 pp.

Columbia River Fish Management Plan (CRFMP). 1988. Entered into pursuant to United States v. Oregon (Civ. 68-513. Federal District Court of Oregon, 1969)

Columbia River Inter-Tribal Fish Commission (CRITFC) 1995. *Wy-Kan-Ush-Mi Wa-Kish-Wit:* Spirit of the Salmon. The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes Columbia River Inter-Tribal Fish Commission, Portland, Oregon.

DeVore, J.D., B.W. James, D.R. Gilliland, and B.J. Cady. 1998. Effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and determine the status and habitat requirements of white sturgeon populations in the Columbia and Snake rivers upstream from McNary Dam. Annual Progress Report, April, 1996-March, 1997, Report B. Report prepared for Bonneville Power Administration Project 86-50, Contract No. DE-A179-86BP63584. Washington Department of Fish and Wildlife, Vancouver, WA. 36p.

DeVore, J.D., B.W. James, and D.R. Gilliland. 1999. Effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and determine the status and habitat requirements of white sturgeon populations in the Columbia and Snake rivers upstream from McNary Dam. Annual Progress Report, April, 1997-

March, 1998, Report B. Report prepared for Bonneville Power Administration Project 86-50, Contract No. DE-A179-86BP63584. Washington Department of Fish and Wildlife, Vancouver, WA. 38p.

Doppelt, B., M. Scurlock, C. Frissell, and J. Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Washington D.C.

Dunne, T., and L. B. Leopold. 1978. Water in Environmental Planning. W. H. Freeman and Company. New York.

Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E .Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries, Volume II: species life history summaries. Estuarine Living Marine Resources Program Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland. 329 p.

Environmental Protection Agency. 1999. EPA Web site: epa.gov/owow/tmdl/intro.html.

Everest, F.H., N.B. Armantrout, S.M. Keller, W.D. Parante, J.R. Sedell, T.E. Nickelson, J.M. Johnston, and G.N. Haugen. 1985. Salmonids. Pages 199-230 in E.R. Brown, editor. Management of wildlife and fish habitats in forests of western Oregon and Washington. Publication R6-F&WL-192-1985. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Portland, Oregon.

Forest Ecosystem Management Assessment Team. 1993. Forest ecosystem management: an ecological, economic and social assessment. Report of the Forest Ecosystem Management Assessment Team. U.S. Government Printing Office 1993-793-071. U.S. Government Printing Office for the U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Land Management, National Park Service; U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service; and U.S. Environmental Protection Agency.

Fraley, J.J., and B.B. Shepard. 1989. Life History, ecology and population status of migratory bull trout (Salvelinus confluentus) in the Flathead Lake and River System, Montana. Northwest Science 63(4):133-143.

Francis, R. C. and Hare. S.R. Decadal-scale regime shifts in the large marine ecosystems of the Northeast Pacific: a case for historical science. Fish. Oceanogr. 1994; 3(4):279-291.

Frissell, C. A. 1993. A new strategy for watershed restoration and recovery of Pacific salmon in the Pacific Northwest. Prepared for the Pacific Rivers Council, Eugene, Oregon.

Fulton, L.A. 1968. Spawning areas and abundance of chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River Basin—past and present. U.S. Fish and Wildlife Service Special Scientific Report—Fisheries no. 571. 26 p.

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin—past and present. U.S. Fish and Wildlife Service Special Scientific Report—Fisheries no. 618. 37 p.

Groot, C., and L. Margolis, editors. 1991. Pacific salmon life histories. University of British Columbia Press. Vancouver, British Columbia. 564 p.

Hare, S. R.; Mantua, N. J., and Francis, R. J. Inverse production regimes: Alaska and West Coast Pacific Salmon. Fisheries. 1999; 24(1):6-15.

Henjum, M. G., J. R. Karr, D. L. Bottom, D. A. Perry, J. C. Bednarz, S. G. Wright, S. A. Beckwitt, and E. Beckwitt. 1994. Interim Protection for late-successional forests, fisheries, and watersheds: national east of the Cascade Crest, Oregon and Washington. The Wildlife Society, Bethesda, Maryland.

Hinch, S. G.; Mealey, M. C.; Diewert. R.E.; Thomson, K. A.; Hourston, R.; Henerson, M. A., and Juanes, F. Potential effects of climate change on marine growth and survival of Fraser River sockeye salmon. Can J. Fish. Aquat. Sci. 1995; 52:2651-2659.

Howell, P. J. and D. V. Buchanan, eds. 1992. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Huntington, C.W., W. Nehlsen, and J. Bowers. 1996. A survey of healthy native stocks of anadromous salmonids in the Pacific Northwest and California. Fisheries 21(3):6-14.

Independent Scientific Group (ISG). 1996. *Return to the River*. Northwest Power Planning Council, Portland, Oregon.

Integrated Hatchery Operations Team (IHOT). 1994. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries. Bonneville Power Administration, Portland, Oregon.

Knudson, K. 1994. Water quality status report, Kootenay (Kootenai) River Basin British Columbia, Montana, and Idaho. Prepared for Kootenai River Network, January, 1994. 57 p.

Lower Columbia River Estuary Program. 1999. Comprehensive Conservation and Management Plan. Volume 1: June 1999. Lower Columbia River Estuary Program, Portland, Oregon. p. 222.

Marcuson, P. 1994. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1990. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-AI79-88BP93497. Project No. 88-65. Portland, Oregon 67 pp.

Marmorek, D.R., Peter, C.N. and Parnell I (eds.) 1998. Plan for Analyzing and testing hypotheses (PATH) Final Report for Fiscal Year 1998. Essa Technologies Ltd.

Marmorek, D., Parnell I., Peters, C.N. and C. Alexander (eds). 1999. PATH: Scoping of Candidate Research, Monitoring and Experimental Management Actions: Concurrently Reducing Key Uncertainties and Recovering Stocks. Working Draft. ESSA Technologies Ltd., Vancouver, B.C., Canada.

McPhail, J.D., and C.C. Lindsey. 1986. Zoogeography of the freshwater fishes of Cascadia (the Columbia system and rivers north to the Stikine). Pages 615-637 in C.H. Hocutt and E.O. Wiley, editors. The Zoogeography of North American freshwater fishes. Wiley and Sons, New York, New York.

Meehan, W.R., and T.C. Bjornn. 1991. Salmonid distributions and life histories. Pages 47-82 in W.R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. American Fisheries Society, Bethesda, Maryland.

Mobrand Biometrics, Inc. 1999. Unpublished report. The EDT method, August 1999 – Draft (Available from Mobrand Biometrics, Inc. Washington).

National Fish Hatchery Review Panel, 1994. Report of the National Fish Hatchery Review Panel. The Conservation Fund, Arlington, Virginia.

National Marine Fisheries Service. 1996. Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale. Guidance document prepared by NMFS Habitat Conservation Division, Portland, Oregon. 31 p.

National Marine Fisheries Service. 1996. Memorandum from William Stelle, Jr., to NMFS/NWR staff, September 4, 1996: Making Endangered Species Act determinations of effects for individual or grouped actions at the watershed scale. (Available from NMFS, Portland, Oregon).

National Marine Fisheries Service. 1997. Description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. Amendment 14 to the Pacific Coast Salmon Plan, Draft Appendix A. January 1999. Pacific Fisheries Management Council Award Number NA87FC008. Portland, Oregon.

National Marine Fisheries Service. 1999a. Recommended Protocols for the Use of Captive Broodstock, Northwest Fisheries Science Center, Seattle, Washington.

National Marine Fisheries Service. 1999b. ESA Section 7 Consultation: Biological Opinion on Artificial Propagation in the Columbia River Basin. March 29, 1999. Portland, Oregon.

National Marine Fisheries Service. 1999c. White Paper: Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams.

National Marine Fisheries Service. 1999d. White Paper: Predation on Salmonids Relative to the Federal Columbia River Power System.

National Marine Fisheries Service. 1999e. White Paper: Salmonid Travel Time and Survival Related to Flow Management in the Columbia River Basin.

National Marine Fisheries Service. 1999f. White Paper: Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams.

National Marine Fisheries Service, U.S. Fish and Wildlife Service. 1999. Fed-1 Plan for Artificial Propagation: Artificial Production Proposal for CRFMP Negotiations. January 7, 1999. Portland, Oregon.

National Research Council (NRC). 1996. *Upstream:* Salmon and Society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids. National Academy Press, Washington D.C.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

North, J.A., L.C. Burner, and R.A. Farr. 1999. Effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and determine the status and habitat requirements of white sturgeon populations in the Columbia and Snake rivers upstream from McNary Dam. Annual Progress Report, April, 1997-March, 1998, Report B. Report prepared for Bonneville Power Administration Project 86-50, Contract No. DE-A179-86BP63584. Oregon Dept. of Fish and Wildlife, Clackamas, OR. 49p.

Northwest Fisheries Science Center (NWFSC). 1999. Anadromous Fish, Appendix A, Draft Report. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Appendix to the Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement. Dated April 14, 1999.

Northwest Power Planning Council. 1986. Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin. Appendix D of the 1987 Columbia River Basin Fish and Wildlife Program. Portland, Oregon.

Northwest Power Planning Council. September 17, 1992. Information on Water Quality and Quantity Contained in the Salmon and Steelhead Subbasin Plans (above Bonneville Dam) (Document 93-8).

Northwest Power Planning Council. 1999. Artificial Production Review. Council Document 99-15. October 13, 1999. Portland, Oregon.

Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW). 1998. Status Report: Columbia River Fish Runs and Fisheries, 1938-1997. Portland, Oregon.

Oregon Water Resources Department. 1993. Memorandum from T. Kline and B. Fujii, Oregon Water Resources Department, to David Moscowitz, et. al., regarding weak stocks and water supply conflicts (September 17, 1993).

Pacific Fishery Management Council (PFMC).1999a. Draft Final Pacific Coast Salmon Plan. Conservation Objectives and Management Information. Portland, Oregon.

Pacific Fishery Management Council (PFMC). 1999b. Review of 1998 Ocean Salmon Fisheries. Portland, Oregon.

Pacific Fishery Management Council Salmon (PFMC). 1999c. Preseason Report: Stock Abundance Analysis for 1999 Ocean Salmon Fisheries. Portland, Oregon.

Paragamian, V. 1995. Kootenai River fisheries investigation: Stock status of burbot and rainbow trout and fisheries inventory. Idaho Department of Fish and Game, Annual Progress Report. Report IDFG 96-7 prepared for Bonneville Power Administration

Project No. 88-65, Contract No. DE-B179-88BP93497. 53p.

Parnell, I., D.R. Marmorek, C.N. Peters, and C.A.D. Alexander (compls./eds.). 1999. PATH: Scoping of candidate experimental management actions. Draft prepared by ESSA Technologies Ltd., Vancouver, B.C. 108 pp.

Quigley, T. M., S. J. Arbelbide (technical editors). 1997. An assessment of ecosystem components in the interior Columbia River basin and portions of the Klamath and Great Basins: Volume 3. Gen. Tech. Rep. PNW-GTR-405. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 vol. (Quigley T. M., tech. ed.: The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment).

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and Habitat Requirements for Conservation of Bull Trout. USDA Forest Service, Intermountain Research Station. Gen. Tech. Rep. INT-302.

Spence, B. C., G. A. Lomnicky, R. M. Huges, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Corp., Corvallis, OR. (Available from National Marine Fisheries Service, Portland, Oregon.)

Standford, J. A., and J. V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. Pages 91-124 *in* R.J. Naiman, editor. Watershed management: balancing sustainability and environmental change. Springer-Verlag, New York.

Stober, Q.J. and Nakatami, R., 1992. Water Quality and Biota of the Columbia River System, in "Water Quality in North America River Systems," Becker, D. and Neitzel, D., Editors, Battelle Press.

Streamnet. December 2, 1999. Glossary of Terms [glossary online]. Gladstone (OR): URL:<http://www.streamnet.org/ff/Glossary.

Thomas, Duncan W. October 1981. Historical Analysis of the Columbia River Estuary: An Ecological Approach. Draft Report to the Columbia River Estuary Study Taskforce.

U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Bonneville Power Administration. 1999. Federal Columbia River power system project operations. Biological assessment for effects of FCRPS operations on Columbia Basin bull trout and Kootenai River white sturgeon. 176 p.

U.S. Department of Agriculture, Forest Service. 1995. Environmental Assessment for the implementation of interim strategies for managing fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of Nevada (INFISH). U.S. Government Printing Office. Washington, D.C.

U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Bureau of Land Management. 1994. Northwest Forest Plan. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl.

U.S. Department of Agriculture, Forest Service and U.S. Department of Interior, Bureau of Land Management. 1995. PACFISH: Decision notice/decision record, FONSI, ES, Appendices for the interim strategies for managing anadromous fish-producing watersheds in eastern Oregon and Washington, Idaho, and portions of California. Washington DC: U.S. Department of Agriculture, Forest Service and U.S. Department of Interior Bureau of Land Management.

Washington Department of Fisheries (WDF), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory. 212 p.

Washington Forest Practice Board. 1995. Rules - WAC 222. Board Manual. Forest Practices Act - RCW 76.09. Washington Department of Natural Resources, Forest Practices Division, Olympia, Washington.

Welch, D. W.; Ishida, Y., and Nagasawa, K. Thermal limits and ocean migrations of sockeye salmon (*Oncorhynchus nerka*): long-term consequences of global warming. Can. J. Fish. Aquat. Sci. 1998; 55:937-948.

8. MAPS