Draft Columbia River Basin Research Plan

by the

Northwest Power and Conservation Council

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I. Planning for the Future, Taking Stock of the Present

Background

For over 20 years the Northwest Power and Conservation Council (Council) has supported a diverse range of research efforts. Hundreds of excellent projects, including dedicated research projects and habitat restoration projects with research elements, have been completed since the inception of the program in 1982. Projects implemented under the Council's fish and wildlife program and others in the Columbia River Basin have substantially advanced the state of scientific understanding of fish and wildlife restoration. Yet the continuing absence of a plan to coordinate research has contributed to a lack of focus on key research needs. (Appendix A. Mandate for a Columbia River Basin Research Plan). To complement its traditionally strong support for research, the Council has drafted this *Columbia River Basin Research Plan* for the primary purpose of guiding the development of a research program under its Columbia River Basin Fish and Wildlife Program (Appendix B. Development of the Columbia River Basin Research Plan).

Many other resource management entities share responsibility with the Council for research in support of fish and wildlife stewardship within the Columbia River Basin. The Council recognized that the status quo for research within the region consists of multiple, separate research plans which make reference to the "need to coordinate" with other similar efforts but rarely set forth any explicit steps to implement such coordination (Appendix C. Implementing the Columbia River Basin Research Plan). The inherent difficulty in agreeing on specific problem definitions, shared funding responsibilities, and overlapping mandates, has resulted in a fragmentation of effort that explains why key research questions within the region persist. Consequently, a secondary purpose of this plan is to provide a programmatic framework upon which to coordinate research and facilitate the integration of disparate research efforts within the region. Now is the time to re-evaluate the Council's approach to conducting research, to reinvigorate the fish and wildlife program's research agenda for the future, and to provide guidance to regional research efforts.

A Research Plan for the Columbia River Basin

Research is necessary to provide scientifically credible answers to questions pertinent to management that are complicated by uncertainty (Appendix D. Sources of Critical Uncertainties and Research Recommendations for the Columbia River Basin). This plan identifies a range of short- and long-term research recommendations. For the purpose of this plan, the term "research" is used broadly and is intended to include more than just dedicated hypothesis testing. For example, "research" may include estimation, pattern recognition, observation, categorization, studies involving the collection of data to better quantify important known relationships, and improvements in statistical methods.

Some research questions in the region have persisted for many years because resource management agencies have been unable to either secure or collaborate on funding commitments necessary to mount the necessary organized, large-scale field experiments. This research plan attempts to divide complex issues into treatable questions. By providing a vehicle for the

identification and organization of these questions, this plan can help the region identify gaps and avoid duplication. It can also help the region with a basis for establishing priorities for new investment and judging the relative priority of continued investment in ongoing research. In brief, the research plan is organized in the following manner:

- First, the plan profiles a pool of critical uncertainties and research recommendations spanning all topic areas relevant to the program. These were identified by the Council's independent scientific review groups, fish and wildlife managers, and other agencies and entities within the Columbia River Basin.

- Second, research recommendations are compared to a summary of current research activity under the fish and wildlife program in order to identify knowledge gaps unaddressed by current research.

- Third, short-term and long-term research priorities are recommended to address the gaps.

Relationship to Existing Research Plans in the Columbia River Basin

The Council developed the draft Columbia River Basin Research Plan to enhance current coordination and facilitate future collaboration. It recognizes other research plans as important components of a potentially integrated regional research program, and provides a framework for establishing linkages between existing research programs and initiatives.

While developing the draft research plan, Council staff reviewed several research plans from within the region and many of the research recommendations they contain have been incorporated into this plan. This plan recommends research to be funded through the fish and wildlife program, as well as recommendations for research that will require collaborative, multi-party funding commitments by the Council and other entities with similar research mandates.

Profile of Current Council Research Projects and Budget

The research projects in the Council's Fish and Wildlife Program address explicit and implicit research needs identified in regional planning documents legally mandated by either the Northwest Power Act or the Endangered Species Act, including:

- The Council's 2000 Columbia River Basin Fish and Wildlife Program, and the Council's 1994 Program as incorporated by reference in the 2000 version;

- The National Marine Fisheries Service's 2000 hydropower biological opinion; and,

- The U.S. Fish and Wildlife Service's 2000 resident fish biological opinion.

The amounts of funding for research projects recommended under the Council's fish and wildlife program for Fiscal Years 2004 and 2005 are presented in Table 1. These projects are categorized by the research topics presented in this chapter. Projects addressing multiple research topics are categorized according to a single primary topic.

Table 1 was generated from a search of project proposals that sorted the projects into research topics based on key words in the proposal titles and short descriptions. Many projects mingled research, restoration, and monitoring activities to a degree that defied easy definition. Therefore, for the purpose of this analysis, research was defined in a general way that could resolve such dilemmas. Specifically, research was defined as work that sought knowledge that would have future and broad benefit. Therefore, projects conducting monitoring for the purpose of current evaluation at the project scale were not deemed to be research. Another example is that work by the Army Corps of Engineers on improving fish passage was defined as research, whereas work under the Fish and Wildlife Program testing the effectiveness of passage strategies was considered monitoring. Consequently, this approach may have missed some research elements, especially those embedded within management, restoration, and monitoring and evaluation projects. A recent trend is that many restoration projects have added research and/or monitoring elements. The most important factor in this analysis was consistency, so all the Council's projects were evaluated by one staff member.

Table 1 also includes preliminary information for FY 05. It does not include relevant research studies pursued under other tribal, agency, university, and private programs, nor does it portray historical research efforts, such as completed or discontinued projects. (The summary information in Table 1 is derived from Appendix E. FY 04 Research Projects Profile, which provides the project proposal identification numbers, project titles and sponsors, and the FY 04 funding levels.)

Table 1. FY 04/05 Council Funding Recommendations by Research Topic

Research Topic	FY04	Percent	FY05	Projects
Hatchery Effectiveness	31,831,721	62.7%	32,085,271	51
Hydropower	202,224	0.4%	175,487	1
Habitat	13,669,649	26.9%	11,825,986	33
Monitoring and Evaluation	327,026	0.6%	219,109	2
Harvest Management	2,720,058	5.4%	1,703,086	2
Natural Variation and Ocean Productivity	1,827,962	3.6%	1,890,113	1
Predation	155,000	0.3%	155,000	1
	50,733,640		48,054,052	91

This information raises two questions for the Fish and Wildlife Program. First is the total amount of spending on research appropriate? Clearly, the current research budget comprises a significant proportion of the overall program budget of $139 million dollars. Considering that some of the remaining budget is spent on management, administration, planning, overhead, and monitoring and evaluation, a relatively smaller share of the budget remains for restoration projects.

The second question is whether the current allocation across the other categories is appropriate. Hydropower appears low given the importance of fish survival, but this is counterbalanced by the Corps' research budget for FY04, including staff engineers, biologists etc., of approximately $40 million that primarily fits into this category (see Table 2). However, the hatchery research budget appears particularly high given the slow progress being made at hatchery reform. In light

of the recent evidence of significant predation on salmon smolts, the amount spent on predation appears especially small. It may benefit the Council to examine the benefits accruing to fish and wildlife from particular research topics with the intention of resetting the allocation of research dollars by topic.

Table 2. Total FY 04 Corps of Engineers Funding Levels for anadromous fish research under the Anadromous Fish Evaluation Program. (Data source: the SCT Spreadsheet and the Fish and Wildlife Operations and Maintenance spreadsheet.)

Topic	CRFM	O&M	Totals
Adult Passage (Salmonids, Kelts, Lamprey, etc.)	2,871,000	1,146,000	4,017,000
Juvenile Passage (Spill, Turbines, etc.)	23,987,000	0	23,987,000
Transportation/Delayed Mortality (D)	2,624,000	2,216,000	4,840,000
Other	50,000	0	50,000
Estuary	4,100,000	0	4,100,000
Predation (Avian primarily)	1,717,000	282,000	1,999,000
	35,349,000	3,644,000	38,993,000

Critical Uncertainties and Research Recommendations for the Columbia River Basin

The next section of this chapter profiles long-standing and contemporary research topics addressing all facets of the fish and wildlife program. The profile for each topic comprises an overview; management needs; critical uncertainties; and the Council's research recommendations. (Please note that not all profiles have all of these elements.) In 1993 the Scientific Review Group defined critical uncertainties:

> "*...as questions concerning the validity of key assumptions implied or stated in the Fish and Wildlife Program. Critical uncertainties identify important gaps in our knowledge about the resources and functional relationships that determine fish and wildlife productivity. Resolution of uncertainties will greatly improve chances of attaining recovery goals in the Fish and Wildlife Program.*"

This section was derived from the works of the independent science groups and the Fish and Wildlife Program. It also contains recommendations from the Army Corps of Engineers, Bonneville Power Administration, NOAA Fisheries, and the Lower Columbia River Estuary Partnership. It is anticipated that the final version of this plan will include additional recommendations from other resource management entities.

Hatchery Effectiveness

Overview: A critical issue facing the region is whether artificial production activities can play a role in providing significant harvest opportunities throughout the basin while also acting to protect and even rebuild naturally spawning populations. Several important research recommendations and critical uncertainties are central to addressing this issue. Columbia River Basin supplementation projects are considered to be experimental. Yet recent reviews have been critical and the science on this issue is far from settled. Two major reviews of hatchery-related issues were completed in 2003, the Artificial Production Review and Evaluation, and the ISAB

Review of Salmon and Steelhead Supplementation. One important criticism from the ISAB's supplementation report is that inadequate replication and widespread failure to include un-supplemented reference streams, coupled with a lack of coordination among projects, make it unlikely that such projects, as currently conducted, will be able to provide convincing quantification of the benefits or harm attributable to supplementation. Some of the key findings include:

1. Artificial production must be used in a manner consistent with ecologically based scientific principles for fish recovery.

2. Fish raised in hatcheries should have a minimal impact on fish that spawn naturally.

3. Fish reared in hatcheries or by other artificial means for the purpose of supplementing the recovery of a wild population should clearly benefit that population.

4. Improperly run, artificial production programs can damage wild fish runs. However, when fish runs fall to extremely low levels, artificial production may be the only way to keep enough of that population alive in the short-term to ensure a chance of recovering in the long term.

5. Hatcheries have been successful at preserving some of the genetic legacy, which would otherwise have been lost, from salmon populations formerly occupying severely degraded habitats.

6. Existing hatchery populations should be protected and carefully evaluated to identify the genetic legacy they contain and its potential role in rebuilding metapopulations.

7. The decision about when and where to deploy supplementation programs should make use of the metapopulation concept.

What is not clear is the extent to which artificially produced fish can be mixed with a wild population in a way that would sustain and rebuild the wild population. The Council has weighed these uncertainties and recognized that inaction also holds a large risk. Hatchery operations including some instances of broodstock selection, inter-basin transfers, and release practices have contributed to the decline of natural production and loss of locally adapted stocks in the basin. Hatchery practices are one of the factors that have altered the genetic structure of stocks in the basin.

Management Needs: This research plan provides a vehicle for addressing how hatchery operations can be integrated into the total production system and should assist in the recovery efforts in the subbasin. The objectives of each hatchery should; be established within the context of the subbasin where the hatchery operates, consider non-target species, and pay attention to the linkages between salmonids and their habitats, and the potential for metapopulation rebuilding. Research should be implemented to address the following management questions:

1. Can artificial production play a role in providing significant harvest opportunities while also protecting and possibly rebuilding naturally spawning populations?

2. Under what conditions can conservation hatcheries be expected to provide a net long-term benefit to the viability of wild populations?

3. Do artificially propagated fish contribute to harvest and/or escapement of naturally spawned fish and is the economic benefit of that contribution greater than its cost?

4. Has the program achieved its objective; e.g., if it is a mitigation hatchery, has it replaced lost natural production?

5. How can hatcheries maintain genetic, behavioral, physiological, and ecological adaptations similar to natural environments?

6. What foods, rearing conditions, and hatchery management practices can favor the establishment of self-sustaining wild runs?

7. Should supplementation proceed independent of programs to restore habitat and improve the productivity of the population in its natural environments?

Critical Uncertainties: Uncertainties exist regarding the potential for both benefits and harm to the naturally spawning populations. A major uncertainty is whether it is possible to integrate natural and artificial production systems in the same basin to achieve sustainable long-term productivity. Some scientists and managers believe that it is likely that supplementation will produce an increased abundance of natural-origin salmon, and that reformed hatchery practices can reduce the risks from supplementation to acceptable levels. Other scientists and managers not only doubt that the expected increases in abundance will be realized, but also believe that there is a high probability that supplementation will cause significant harm, reducing the productivity and abundance of the natural-origin component of the integrated population. In addition, supplementation (with unmarked hatchery fish) can introduce uncertainty through masking the numbers of natural-origin fish, making a determination of reproductive success difficult (for both natural-origin and hatchery-origin fish).

The immediate net demographic benefit or harm to population abundance from supplementation depends on three things: intrinsic biological parameters of the stock in its environment, policy constraints, and management control variables. The integration of these factors, much less their measurement, has not been adequately considered in supplementation evaluations to date. For hatchery programs where the hatchery and natural population are integrated, the empirical basis is inadequate for determining the cost to the natural population. The impacts of these hatchery programs on the extinction risk to, or recovery of, the remaining natural populations of salmon and steelhead have not been determined empirically and these knowledge gaps need to be filled.

At present, little is known about the magnitude of any correlation between natural spawning fitness and hatchery spawning fitness in actual salmon populations. Nevertheless, modeling shows that this relationship has a large influence on the probability and magnitude of the depression in natural spawning fitness as a consequence of supplementation. How a decrease in

the fitness of natural-origin adults due to interbreeding with hatchery-origin adults translates into a reduction in population abundance is unknown.

A major uncertainty associated with the use of supplementation is the condition of the habitat that will receive the juvenile salmon. Is the habitat capable of supporting salmon at levels of survival that will bring about restoration? The ecological conditions required to expect to achieve benefits from supplementation have received little conceptual development or programmatic experimentation.

The Council's Research Recommendations: The genetic risks of supplementation as a means to increase natural spawners suggest that it would be prudent to continue to treat supplementation as experimental, that supplementation should only be deployed on a limited scale, and that better and more extensive monitoring of such experiments should be required to generate an empirical record capable of evaluating those experiments.

1.1 Determine the effects of wild-hatchery fish interactions and the impacts of hatchery management programs on wild stocks.

1.2 Test the assumptions about survival differences between hatchery and wild fish.

1.3 Determine the origin and the temporal and spatial distribution of wild ocean-caught fish.

1.4 Determine the long-term persistence of natural elemental signatures in fish scales.

1.5 Improve the persistence of cold marks at the focus of otoliths in swim up fry to allow for subsequent detection. Although lethal otolith sampling is required to detect marks, this technique may still serve a useful purpose for certain research applications.

1.6 Assess the effectiveness of batch marking of fish scales using applied concentrations of microelements. Micro-elemental marking of fish scales and otoliths may be an alternative to cold marking techniques in hatchery research.

1.7 Determine the exact timing of imprinting in juvenile WCT and Bull trout. Assured imprinting on a specific water source will reduce the potential for straying when fish are planted to establish a new wild spawning run.

Hydrosystem

Overview: In April 2003, following a two-year public process, the Council adopted the mainstem amendments to its Columbia River Basin Fish and Wildlife Program that provide a broad range of recommended policies, operations and specific recommendations for future research. These amendments describe an experimental approach to many of the long-standing uncertainties regarding fish survival through different routes of passage and under different hydrosystem operational scenarios. To implement the amendments, a workplan has been developed that sets forth 45 different tasks, many of which address specific research issues such as tests of dam operations. An important task for the Council is to establish priorities for this Mainstem Amendment work plan (Task 43). An informal internal prioritization based on what needs the most attention from the Council has been conducted by staff, with the focus in being on summer spill and reservoir operations Council staff will carry these recommendations forward into the formal process for establishing priorities in the Regional Forum.

There are more tasks envisioned in the mainstem amendments than the Council's staff and budget resources can adequately cover. For this reason, staff will work with the Council to establish priorities for the tasks included in this work plan. This will help focus the Council's resources and advise other agencies on those tasks that offer the most immediate benefits and are likely to be the most important to achieving the Council's vision for the basin.

The Council calls for specific changes in current operations in an experimental fashion that will help to shed more light on the biological needs of fish and wildlife. This section of the research plan is derived from the workplan for the mainstem amendments. (Some additional hydropower research recommendations appear in the monitoring and evaluation section of this chapter.)

Management Needs:

1. Determine more precisely the relationship between fish survival and various levels of spill at the individual dams and for the system.

2. Implement and test new spill technologies such as removable spillway weirs.

3. Evaluate turbine operations at the different dams to determine optimum fish survival through the turbines and tailrace environment.

4. Evaluate the benefits of incremental flow augmentation and determine the mechanisms for flow/survival relationships on the Columbia and Snake rivers.

5. Evaluate the biological effects of steady June through September outflows from Libby and Hungry Horse dams in Montana.

6. Evaluate and document the impact of predation in the mainstem in terms of numbers of ESA-listed fish taken, and estimated impact on smolt-to-adult return ratios.

7. Evaluate and document the impact of harvest operations in terms of numbers of ESA-listed fish taken, and estimated impact on smolt-to-adult return ratios.

8. Improve the effectiveness of the adult passage program. Evaluate the benefits of cool water releases from reservoirs to facilitate adult migration.

9. Monitor smolt to adult return ratios. Investigate the possibility of achieving the Council's interim objective of achieving smolt-to-adult survival rates in the 2-6 percent range for listed Snake and Columbia river salmon and steelhead.

10. Identify research that is needed to clarify habitat conditions in all of the mainstem reservoirs.

11. Test other uncertainties proposed by the independent science panels and fish and wildlife managers summarized in this research plan.

Critical Uncertainties: The cumulative indirect effects of passing multiple dams during migration are uncertain. The cumulative effects of predation must be evaluated including marine

mammals, avian species (e.g. terns, cormorants, mergansers), as well as piscivorous fish (e.g., pike-minnow, walleye, and smallmouth bass). Further, the relationship between levels of flow and juvenile and adult salmon survival through the Columbia hydrosystem needs greater clarification. The present flow management strategy does not take into account the complex migratory behaviors of juvenile salmonids. For example, there is considerable uncertainty about the effects that changes in river flows designed to aid yearling migrants has had on subyearlings.

Water budgets (basinwide, annual rule curves for water storage and release) need to be rigorously evaluated to determine what is actually being accomplished for survival of salmonid populations. The effects of augmented flows on rearing fall Chinook in unnaturally cold reaches of the Snake and Clearwater rivers must be determined.

The role of hydrodynamic features other than mid-channel velocity in fish migration needs to be explored. A proven link to such features as stage waves and turbulent bursts, or pulsing flows may offer opportunities for water management that might be more effective in moving fish with less water than current procedures. The secondary effects of flow differences on nearshore habitat conditions of present-day reservoirs (temperature, flow, and food production) need to be measured and evaluated. The effects of shoreline modifications along reservoirs (rip-rap, erosion, and permanent sloughs) compared to the riverine condition need to be evaluated.

Little is known about the cumulative effects on survival of both adults and juvenile salmon from spilling water to gas supersaturation limits of 120 percent in the tailrace and 115 percent in the forebay at all mainstem projects. The relationship between inriver gas supersaturation levels and salmonid inriver survival is not well understood because (a) the supersaturation-exposure histories of inriver fish are not well understood, and these variable exposures are not easily related to laboratory dose-response experiments, and (b) injured fish can be lost through predation, disease, or other ecological factors that are not well quantified at the present time.

The Council's Research Recommendations:

2.1 Design a comprehensive research program that will integrate specific passage research at each dam and through each passage route with overall system survival evaluations.

2.2 Implement summer spill tests as soon as possible to examine the benefits of the current summer spill program for outmigrating juvenile fall Chinook.

2.3 Conduct research necessary to design, test, and implement new surface passage systems, e.g. removable spillway weirs.

2.4 Continue to develop rigorous evaluations of spillway passage at each mainstem project. Determine an optimal passage strategy at each dam and for each passage route that maximizes improvements in life-cycle survival.

2.5 Continue to evaluate biological effectiveness and costs of spill operations. Provide a systematic evaluation of the biological and cost effectiveness of using spills as a passage strategy.

2.6 Implement an experimental operation at Libby that will limit the summer draft to 10 feet from full pool by the end of September.

2.7 Implement an experimental operation at Hungry Horse that will limit the summer draft to 10 feet from full pool by the end of September.

2.8 Determine the feasibility and implement research as necessary to evaluate the biological effects of flow augmentation from Libby and Hungry Horse on salmon survival in the Lower Columbia River. Design and implement new survival tests in the lower river to better understand the movement and survival of fall Chinook.

2.9 Continue to evaluate turbine passage to determine the optimum fish survival through turbines. Continue the research and design work on improved turbines and the relationship between survivals and overall turbine operating efficiencies.

2.10 Modify turbine designs to improve juvenile salmon passage survival. Evaluate alternative designs and implement as soon as possible in those dams where they would provide the greatest biological benefits.

2.11 Continue to evaluate survival benefits of transport from McNary Dam to determine whether the survival benefits of transport from McNary are sufficiently greater, at least under certain circumstances, than inriver passage to justify continuing (or increasing) the transport effort from that dam.

2.12 Conduct a transportation study targeting Snake River fall Chinook. Evaluate relative success of transporting various groups of fish throughout the Snake River.

2.13 Determine the differential delayed mortality "D" effects due to transport.

2.14 Investigate and implement actions to reduce toxic contaminants from entering the Snake and Columbia rivers.

2.15 Review operational procedures to identify efforts that could be taken to avoid exceeding total dissolved gas saturation limits of 120 percent, over a time period of the twelve highest hourly measurements at all Federal Columbia River Power System projects engaged in spill operations.

2.16 Determine the feasibility and perform as necessary the research to determine the survival benefits of lowering total dissolved gas levels from the waiver amount of 120 percent to the Total Maximum Daily Load of 110 percent.

2.17 Determine the effects of predation on salmonid recovery and how predation is affected by other environmental factors.

2.18 Evaluate the impact of predation on fish survival and smolt-to-adult return rates.

2.19 Determine the factors influencing predation rates on salmonid smolts in the Columbia River estuary.

2.20 Continue to improve estimates of the impacts of seabird predators on wild salmonids.

2.21 Improve the estimates of the impact of pinniped predation on salmonid stocks and on the recovery of depressed stocks.

Habitat

Overview: Habitat required for salmonid migration, spawning, egg incubation and juvenile rearing has been severely degraded in the Columbia Basin by the cumulative effects of flow regulation by dams and diversions, sedimentation from forestry and agricultural activities, and massive introduction of non-native fish, invertebrates and riparian plants. Much of the alluvial floodplain and associated habitats that historically supported large, productive spawning populations and provided high-quality rearing habitats for maturing and migrating juveniles, has

been destroyed by reservoir inundation, degraded by altered flows from hydropower, flood control, and irrigation, or disconnected from the salmon ecosystem by dams that block migratory pathways.

Sustained salmonid productivity requires a network of complex and interconnected habitats, which are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean. Ocean conditions, which can be variable, are important in determining the overall patterns of productivity of salmon populations. Restoration efforts must focus on restoring habitats and developing ecosystem conditions and functions that will allow for expanding and maintaining diversity within, and among, species in order to sustain a system of robust populations in the face of environmental variation. Incremental loss of incubation, rearing and spawning sites has reduced or eliminated production of salmonid stocks and disrupted natural metapopulation structure and dynamics.

Life history diversity, genetic diversity, and metapopulation organization are ways salmonids adapt to their complex and connected habitats. These factors are the basis of salmonid productivity and contribute to the ability of salmonids to cope with environmental variation that is typical of freshwater and marine environments. Owing to the diverse climates and food web assemblages of the different eco-regions that comprise the Columbia River Basin, native salmonids displayed great diversity of life history types (stocks or populations) specifically adapted to the wide array of natural habitats. Thus, diversity has been substantially depleted by habitat loss, fragmentation and degradation.

Management Needs:

1. Quantify the benefit to aquatic species of on-the-ground habitat restoration and protection measures.

2. Determine the value of salmon pellets/carcasses to increase habitat productivity.

3. Identify and protect habitat that supports existing populations that are relatively healthy and productive.

4. Identify and expand (reconnect) adjacent habitats that have been historically productive or are likely to sustain healthy populations.

5. Identify and rebuild healthy, naturally producing fish and wildlife populations.

6. Protect and restore habitats and biological systems.
7. Identify ecosystem conditions and functions that expand or maintain diversity within and among species.

8. Identify possible improvements to conditions in the estuary and plume?

9. Account for changes in fish survival with the variable nature of the ocean?

10. Identify current and critical habitat needs in the mainstem of the Columbia and Snake rivers

and seek to increase the extent, diversity, complexity and productivity of mainstem habitat by protecting, enhancing and/or connecting mainstem spawning, rearing and resting areas.

Critical Uncertainties: In the face of uncertainty about the sufficiency of current land use practices, designation and protection of a well-distributed network of reserve areas and habitat patches from new land-disturbing activities is necessary to establish experimental natural baselines. Although "best management practices" (BMPs) may reduce impacts to habitat compared to unregulated land use, uncertainty about effectiveness of present BMPs must be resolved by scientific evaluation at both site-specific and watershed scales. The nutritional state of migrating salmonids requires research in relation to stability and productivity of food webs, including importance and effects of colonization of mainstem reservoirs by estuarine species and value of macrophytes for producing food for mid-Columbia salmonids. It is important to re-establish the seasonality of flow and temperature and to stabilize base flow and temperature fluctuations. The exact magnitude and timing of restored flows and temperature regimes need to be empirically determined for specific free-flowing segments and requires a broadly multidisciplinary approach.

The relationship between habitat and salmonid productivity is dynamic. Understanding this relationship is critical to conserving and restoring habitat that will meet population-based salmonid restoration, recovery, and conservation. Therefore, a comprehensive life-cycle approach that addresses both natural variability in environmental conditions and human impacts on physical, chemical, and biological processes that affect salmonids needs to be defined. NOAA Fisheries' 2000 Biological Opinion calls on the federal Action Agencies, in conjunction with the Environmental Protection Agency and the U.S. Geological Survey, to develop a program to 1) identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships and identify research needs; 2) develop improvement plans for all mainstem reaches; and 3) initiate improvements in three mainstem reaches.

The Council's Research Recommendations:

3.1 Test the effectiveness of new timber harvest prescriptions, sustainable agriculture practices, and other land use practices for upland and riparian areas, in short- and long-term studies before considering them sufficient for conserving and enhancing water quality and salmonid habitats.

3.2 Identify and protect a well-distributed network of reserve watersheds and riverine habitat patches to establish experimental natural baselines for evaluation of effectiveness of management practices.

3.3 Conduct an integrated assessment of the role of food and feeding on the nutrition of downstream migrants leading to conclusions regarding action options for restoration of riverine food chains such as induced flooding, riparian habitat restoration) and promotion of estuarine food chains, for example species stocking.

3.4 Test, through field studies, the nutritional state of migrating Snake River salmonids in relation to that of mid-Columbia stocks, to estimate the importance of food availability to salmon survival.

3.5 Estimate, through field studies of insect colonization and growth during flooding and spatial analyses of floodplains, the quantity of salmonid food potentially produced by

flooded riparian lands in the lower Columbia-Snake basins and lost by river regulation, and relate quantitatively to the food requirements of migrating juvenile salmon.

3.6 Determine, through field studies, the current extent of the colonization of reservoirs by estuarine species and their role in reservoir food webs.

3.7 Estimate, through field studies and laboratory feeding experiments, the importance of longitudinal continuity of food for relative survival of mid-Columbia (Hanford) and Snake River migrants

3.8 Estimate, through field studies, the value of macrophytes for producing food for mid-Columbia salmonids

3.9 Continue to evaluate the nutritional status of juvenile salmonids during transportation from upper river dams to below Bonneville Dam.

3.10 Evaluate nutrient cycling, carcass increases, and productivity of macro-invertebrates.

3.11 Continue to provide storage reservoirs with selective withdrawal systems to more normalize or mitigate the annual temperature cycle in the river.

3.12 Determine how temperatures in tributaries are part of the environmental change that has fragmented salmonid habitat, and develop programs to improve tributary temperatures for salmonids.

3.13 Continue to evaluate the amount of spawning habitat for fall Chinook core populations in the lower and mid-Columbia area and in the lower Snake area.

3.14 Enhance the abundance and productivity of white sturgeon in the mainstem.

3.15 Conduct the necessary feasibility studies to restore, where feasible, anadromous fish to blocked areas.

3.16 Determine the impacts of declining wild salmonid populations on ecosystem processes, such as the transport of marine derived nutrients from ocean to upland settings.

3.17 Identify habitat elements necessary for bull trout and develop an inventory of streams that provide the cold-water habitat conditions necessary for bull trout.

3.18 Determine the importance of protecting mainstem habitat for recovery of bull trout.

3.19 Document the amount and timing of flows in subbasin plans, in order stabilize and improve burbot populations in the Kootenai River.

3.20 Assess habitat carrying capacity needs, within the stream reaches and subbasins where supplementation is being conducted and throughout the required migration route.

3.21 Determine how changes in plant communities, including riparian and upland vegetation, can affect salmonid habitat quality.

3.22 Determine relationships between habitat quality and population trends of salmonids in estuaries, lowland streams, and urban/suburban and agricultural settings.

3.23 Determine the effects of livestock browsing on aspen sprouts.

Recovery Planning

Overview: Different species and populations of salmonids in the Columbia River and elsewhere exhibit remarkable life history, ecological, behavioral, phenotypic, and genetic diversity. This diversity is a hallmark of salmonids in general and arose from differential or local adaptation to

the varied and variable environments within the complex landscapes of the Pacific Northwest. Such diversity buffers salmonid populations against short- and long-term environmental variation and has become even more important today as human activities have increased the rate and amplitude of environmental fluctuations over those that occurred historically.

The importance of local adaptation to salmonid populations has been underestimated. Generally there has been a lack of success in salmonid introductions and re-establishments within the basin. Diversity has been reduced by the extinction of many local populations, as well as a reduction in population size of most remaining populations. Losses of genetic diversity may have decreased the reproductive and ecological fitness, and therefore decreased the probability of long-term persistence for many stocks.

Under unconstrained conditions, metapopulation structure would act to stabilize losses of diversity and reproductive fitness within individual populations. Yet human-caused development has altered the organization of salmon populations and consequently probably altered metapopulation organization. This has very likely caused losses in adaptive capacity and resulted in a reduction in regional stability of production. Present restoration efforts have focused primarily on remaining satellite populations, which are smaller and less productive and may have higher probabilities of extinction than core populations. Human development and management actions have increased the potential for synchrony among geographically diverse local populations. This may have rendered present metapopulation organization more sensitive to the effects of regional variation by reducing metapopulation size, increasing local population extinction rates, and reducing dispersal between populations. Nevertheless, salmon populations in the Columbia River today can still form the base for rebuilding salmon abundance and diversity.

After population identification, the next step in the technical recovery planning process is to develop biological criteria for population and ESU viability. In determining biological viability criteria, the NOAA Technical Recovery Teams, or TRTs, generally follow the guidelines discussed in the *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (NOAA Technical Memorandum NMFS-NFWSC-42, June 2000). The TRTs, are technical workgroups convened and chaired by NOAA Fisheries to determine the preliminary biological criteria necessary to ensure the viability of Evolutionarily Significant Units, or ESUs, listed under the ESA.

Management Needs:

1. Identify strong, weak, and at-risk native populations and determine what actions can be taken to preserve and protect native populations.

2. The importance of stock diversity must be explicitly recognized in all aspects of the restoration effort.

3. Ensure that monitoring and evaluation can verify whether or not certain life history types are favored, or selected against, by the restoration action?

Critical Uncertainties: Populations are often the fundamental unit of viability analysis, so effectively evaluating the status of a species may depend on correctly understanding its population structure (CENR, 2000). For restoration and recovery actions to succeed, there must be understanding of how these distinct populations individually respond to environmental variables that are likely controlled by very different limiting factors. Sub-watershed and site-specific restoration and recovery actions must be tailored to specific populations and to their particular environmental and biological attributes (CENR, 2000). The first step is to identify the "independent populations" within an ESU, as these are the basic building blocks for the recovery of the ESU.

The Council's Research Recommendations:

4.1 Determine whether fisheries management practices such as harvest, dam operations, hatchery operations, and transportation have reduced variation in salmonid stocks.

4.2 Determine the extent that the use of hatchery stocks may have reduced the between-population component of genetic variation in some species, such as Lower Columbia River coho and Upper Columbia River Chinook.

4.3 Determine whether re-establishment of metapopulation structure between Columbia Basin salmon populations would slow or stabilize the loss of diversity in isolated local populations?

4.4 Identify and characterize interactions among basin populations, metapopulations, ocean survival rates, life history stage (survival) trends, and population viability.

4.5 Integrate analysis of habitat characteristics and spawner surveys with models to assess trends in population dynamics and conduct sensitivity analysis of models and model parameters.

4.6 Determine distribution of spawner abundance relative to spawning habitat of differing quality.

4.7 Determine the genetic basis of various life history strategies in salmonids.

4.8 Increase the number of genetic markers to enable researchers to determine the genetic integrity of individual fish to help select appropriate donor parents for replicating unique genetic strains of fish that are threatened by extirpation.

4.9 Develop a set of precise quantitative definitions that link ESU, "independent population", and "subpopulation".

4.10 Combine the definitions in 11.2 with a set of decision rules indicating how viability will be assessed for "independent populations," how the viability of component independent populations," within an ESU will determine ESA status for that ESU, and what burden of proof will apply to setting boundaries of "independent populations," when the data are incomplete and the conclusions uncertain.

4.11 Determine effectiveness and feasibility of using artificial propagation in bull trout recovery.

4.12 Identify status, limiting factors, and management alternatives for lamprey.

4.13 Determine capacity of each potential local bull trout population.

Monitoring and Evaluation

Recognizing that research and monitoring are different types of activities, this section sets forth research needs within the field of monitoring and evaluation. The CENR (2000) report recommended that research efforts in the area of monitoring and evaluation would greatly enhance the scientific credibility of salmonid restoration and recovery plans by providing timely feedback to managers and policy makers.

Overview: Understanding the effect of habitat conditions on anadromous and resident fish and wildlife population performance requires replicated observational studies or intensive research level experiments to be conducted at large spatial and long temporal scales. Few evaluations of tributary habitat in the Columbia Basin meet these criteria. The expense and effort needed to obtain the data necessary for evaluating the response of salmonids to habitat restoration is considerable. It is likely to require several generations of a population to get statistically supported answers to questions about the effectiveness of habitat restoration. This supports an approach of focusing intensive monitoring efforts on a relatively few locations and to involve multiple parties in a collaborative research effort. By implementing these evaluations with clear objectives, careful employment of experimental and statistical design, disciplined adherence to the experimental constraints in treatment and reference sites, and patience, results can be obtained that will greatly improve the ability to ensure viable fish and wildlife populations.

For salmon and trout, the goal of most habitat restoration efforts is to improve survival through their entire period of freshwater residency. Individual restoration projects should collectively contribute to the attainment of this objective. To determine whether this is occurring, projects applied at the reach scale should be nested within, and clearly related to, the watershed-level objective for habitat condition and fish populations. Such a nested hierarchy creates an interconnectedness among projects that is critical to assessing the effectiveness of the restoration efforts through a monitoring and evaluation program. The Pacific Northwest Aquatic Monitoring Partnership has drafted a Regional Monitoring Coordination Plan in response to the request of the four Governors that provides a framework for coordinating current and future monitoring efforts of the states, tribes, and federal agencies and is complementary to this research plan. However, this plan does identify research in support of monitoring and evaluation.

Management Needs:

1. Monitor and evaluate the effectiveness of habitat improvement projects.

2. Monitor and evaluate the habitat improvement projects making the most of scarce resources.

The Council's Research Recommendations:

5.1 Develop a sound Tier I trend-monitoring procedure based on remotely sensed data obtained from sources such as aerial photography or satellite imagery.

5.2 Develop and implement a long-term statistical monitoring program (Tier 2) to evaluate the status of fish and wildlife populations and habitat. This action would entail development of probabilistic (statistical) site selection procedures and establishment of common

protocols for cost-effective "on the ground" or remotely sensed data collection of a limited number of indicator variables.

5.3 Develop or improve existing empirical models for prediction of abundance or presence-absence of focal species as data are obtained in a Tier 2 status-monitoring program.

5.4 Implement a research monitoring (Tier 3) effort at selected locations in the Columbia Basin to establish the underlying causes for the changes in population and habitat status identified in Tiers 1 and 2 monitoring.

5.5 Continue to determine the relative proportion and survival of migrating juvenile salmonids passing through the various passage routes, including spillways, located at the mainstem dams.

5.6 Continue to determine the differences in migration timing and relative survival for transported and inriver juvenile salmon and steelhead. Determine the relationship between ratios of transport and inriver return rates and measurements of juvenile survival (D values).

5.7 Continue to determine how specific flow and spill conditions affect passage success of adult salmonids migrating past the mainstem dams.

5.8 Continue to determine what the effects of multiple juvenile fish bypass are on juvenile salmonids migrating through the mainstem dams.

5.9 Determine the biological and physiological effects on wild and hatchery juvenile salmonids that are exposed to stress from bypass, collection, and transportation at the mainstem dams.

5.10 Continue to determine the effects of flow on survival, growth, migration timing, and smolt to adult return ratios of juvenile salmonids in the Columbia and Snake River basins.

5.11 Continue to determine juvenile hydro survival (priority total system/secondary in-river) in relation to performance standards.

5.12 Continue to determine the adult hydro survival in relation to performance standards.

5.13 Continue to determine the effectiveness of transportation versus in-river migration.

5.14 Continue to determine the reproductive success of hatchery fish spawning in the wild relative to wild fish.

5.15 Determine the effects that hatchery reforms have in reducing extinction risk of listed species and contributing to recovery.

5.16 Determine the extent of harvest incidental mortality imparted on non-targeted, listed species.

5.17 Determine the extent of harvest incidental mortality in terms of impact on pre-spawning survival and spawning success for listed species.

Harvest Management

Overview: The exploitation incurred by fishing and other natural resource extraction activities on salmon reduced the production of salmon in the Columbia River Basin. Traditional harvest management, through imposition of limits on exploitation in directed salmon fisheries, has been insufficient to allow salmon populations of the Columbia River to persist at sustainable and harvestable levels.

Harvest management has failed to consider the relation of salmon abundance to other components of the ecosystem, which are connected by the life cycle of the salmon. Harvest regulation is a sufficient means of protecting and increasing salmon production only in the presence of reasonably pristine habitat. Estimates of salmon production from habitats that are constantly declining in productivity will always be too high. Harvest is a factor limiting their recovery, yet harvest restrictions in the absence of habitat restoration are not sufficient to permit recovery. Overfishing results when estimates of harvestable surplus are too high. A new harvest management paradigm is needed that will take habitat productivity into account.
The ISAB is reviewing the scientific issues associated with harvest management, for example the establishment of biological management goals, the information needs for monitoring and evaluation, and relationship to recovery planning. The report will address the fundamental question of what constitutes a sound scientific basis for the management of Pacific salmonids in the Columbia River Basin. The ISAB is evaluating the ability to manage for smaller population groups given current methodologies, the concept of over-spawning, the role of salmon in the ecosystem, the treatment of uncertainty in stock assessments and management evaluation, and the assessment of harvest within a life cycle and recovery context. The harvest review will also include an examination of the effects of climate variability on the marine environment and the interplay of harvest, hatchery production, and varying ocean regimes. Harvest remains an important scientific issue and could become increasingly so in the immediate future if marine survival continues to improve resulting in large returns of some stocks.

Management Needs:

1. Identify and implement the equipment and marking techniques necessary to establish selective harvest techniques.

2. Develop an interim policy regarding the operation and harvest management of production from each hatchery where monitoring has been inadequate to complete a comprehensive evaluation.

3. Determine the level of escapement at the watershed scale necessary to ensure that over-harvest is not taking place?

4. Determine what evidence exists regarding stock-composition and stock-specific abundance, escapement, catch, and age distribution.

Critical Uncertainties:

1. Directed and incidental harvest of Columbia River Basin salmon has occurred in the absence of knowledge of harvest impacts on the abundances and viabilities of the majority of the individual native spawning populations.

2. Most Columbia Basin stocks are at low levels such that harvest in the ocean would have to be very low or non-existent to allow the habitat restoration proposed in the fish and wildlife program and the biological opinions to have a reasonable chance to succeed.

3. Uncertainties exist regarding stock-composition and stock-specific abundance, escapement, catch, and age distribution.

The Council's Research Recommendations:

6.1 Develop harvest levels that take into consideration the relation of salmon abundance to other components of the ecosystem that are connected by the life cycle of the salmon.

6.2 Determine how to base sustained-yield management of a salmon population on numerical spawning escapement goals at the watershed level, which represent both the productive capacities of the habitats for the salmon population and all related salmon populations.

6.3 Evaluate innovative techniques to improve access to harvestable stocks and reduce undesirable direct and indirect impacts to wild populations.

6.4 Evaluate appropriateness of stocks used in weak stock management.

This section will be updated based on the ISAB Harvest Management review scheduled for completion in January 2005.

Estuary

Overview: The Columbia River estuary is an important ecological feature of the Columbia River Basin, constituting the physical and biological interface for salmon and trout as they transition between their freshwater and ocean life stages. Juvenile salmon utilize various areas in the estuary to rear and undergo adaptation to marine conditions. Rearing locations, seasonal timing, residence timing, and migration pathways differ between species and stocks.

The Columbia River estuary also provides important rearing habitat for other animal species of marine origin, and year-round habitat for species that have evolved to live solely within an estuarine environment.

The Columbia River estuary has undergone tremendous changes as a result of settlement and development, and these affected its physical character and biological resources. Physical characteristics such as depth, velocity, salinity, temperature, and turbidity vary dynamically within the Columbia River estuary, presenting a highly variable environment. The environmental changes that have occurred have substantially affected habitat availability, habitat quality, species composition, and other biological attributes of the estuarine ecosystem. The complexity of the physical and biological processes and interactions within the Columbia River estuary system contribute to the challenges and opportunities faced by aquatic organisms, including salmon and trout. While less is known about the potential for improvement in the estuary compared to other parts of the Columbia River Basin, there are indications that substantial improvements are possible, and that these improvements may benefit anadromous fish populations.

Characterization of the estuary's physical and biological attributes that support salmon is underway, but is in its infancy. The draft NMFS report, *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon*, assessed the potential impact of flow regulation on juvenile salmon utilization of the estuary. The report found that hydrologic and climate factors likely have consequences for the estuarine physical environment. However

with the existing data it is not possible to separate these effects from compounding factors or to rank these factors' effects on salmon. Yet, it is clear that changes in the food web have occurred that affect the estuary's capacity to support juvenile salmon and that have reduced habitat complexity.

The ISAB recommended an aggressive experimental program to reduce the likelihood of prolonged uncertainty about the impact of estuarine conditions. The ISAB also recommended incorporating monitoring of the physical environment, such as that currently under way by the Oregon Graduate Institute, with evaluation of large-scale manipulations of estuarine habitats. The intent of these restoration treatments would be to study changes presumed to have had negative impacts and to conduct these at a scale that can be measured within the natural environment.

Management Needs:

1. Determine what actions in the estuary are most beneficial to improving survival.

2. Changes in the biological processes vary from a fundamental alteration in the basis of the food web to the exclusion of sub-yearling Chinook and chum salmon from a large portion of the tidal marshes. Determine how the effects of these specific changes can be partitioned from the effects of numerous other impacts in the basin?

Critical Uncertainties:

1. The impact of the significant loss of peripheral wetlands and tidal channels is uncertain. These habitats are important to the early rearing, survival and growth of chum salmon, sub-yearling Chinook, and smaller coho salmon in other West Coast estuaries.

2. The effects of change in seasonal flows following the development of the hydrosystem are uncertain. Those effects are closely associated with the impact of the development of the navigation channel. In combination these developments have resulted in changes to estuarine circulation, deposition of sediments, and biological processes.

The Council's Research Recommendations:

In 2003 the Lower Columbia River and Estuary Partnership (LCREP) and the Army Corps of Engineers sponsored a Lower Columbia River and Estuary Research Needs Identification Workshop. The following list of research recommendations is largely drawn from the proceedings of that workshop. The types of large-scale restoration programs to be evaluated include:

7.1 Evaluate removal of dikes in the lower river and upper estuary to restore connections between peripheral floodplains and the river or fluvial zone of the estuary.

7.2 Determine how to manage sources of salmonid predation in the estuary through restoration of natural habitats, removal of habitats artificially created due to channel construction and/or maintenance, or controlling predator populations.

7.3 Determine an allocation of water within the annual water budget for the Basin, that would simulate peak seasonal discharge, increase the variability of flows during periods of salmonid emigration, and restore tidal channel complexity in the estuary, aided by removing pile dykes where feasible.

7.4 Implement selected restoration projects as experiments, with pre- and post-restoration project monitoring programs.

7.5 Determine the effectiveness of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.

7.6 Determine additional shallow water bathymetry data needs for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.

7.7 Identify priorities for off-site mitigation projects in Columbia River Estuary tributaries.

7.8 Conduct genetic research to identify genotypic variations in habitat use.

7.9 Conduct research on food web dynamics.

7.10 Conduct research on sediment transport and deposition processes in the estuary.

7.11 Conduct research to understand juvenile and adult migration patterns.

7.12 Conduct research on the linkages between physical and biological processes.

7.13 Conduct research on the effect of toxic contaminants on salmonid fitness and survival in the Columbia River Estuary and ocean.

7.14 Conduct research on the effects of invasive species and the feasibility to eradicate or control them.

7.15 Conduct research on the role between micro- and macro-detrital inputs, transport, and end-points.

7.16 Evaluate flow effects, river operations, and estuary-area habitat changes on the relationship between estuary and near-shore plume characteristics and the productivity.

Natural Variation and Ocean Productivity

Overview: Global and regional-scale processes in the ocean and atmosphere can regulate the productivity of local marine, estuarine, and freshwater habitats for salmon. Although managers cannot control these processes, natural variability must be understood to correctly interpret the response of salmon to management actions in the Columbia Basin.

Salmon abundances in the California Current region (off Washington, Oregon, and California) and in the Central North Pacific Ocean domain (off British Columbia and Alaska) respond in opposite ways to shifts in climatic regime. During periods of a strong Aleutian Low, zooplankton and salmon production generally increase in the Central North Pacific and decrease in the California Current, suggesting geographically distinct mechanisms of aquatic production. Climatic shifts characteristic of the strong Aleutian Low regime occurred twice this century: one from about 1925 to 1946 and another in 1976/77 to the present. Both periods were marked by precipitous declines in the coho salmon fishery off Oregon. Opposing cycles of salmon abundance between the Central North Pacific and the California Current regions underscore the importance of stock-specific regulation of ocean fisheries. Even during periods of high marine survival off Oregon, harvest limits must ensure that Columbia Basin stocks are not overexploited by northern fisheries trying to compensate for coincidental decreases in the production of stocks from Alaska and British Columbia.

Salmon migrations are tied to major ocean circulation systems and yet salmon life cycles are shorter than the inter-decadal periods of large-scale climatic change. The abundance of salmon tracks large-scale shifts in climatic regime, yet the specific mechanisms of this tracking are poorly understood. Stocks with different life history traits and ocean migration patterns may be favored under different combinations of climatic regime and local habitat characteristics. Such differences afford stability to salmon species over multiple levels of environmental variability.

Decadal cycles of ocean productivity have the potential to mask changes in the survival of salmon during freshwater phases of their life cycle, leading to erroneous interpretation of the performance of restoration efforts and increased losses of some stocks. The dynamics of salmon metapopulations will change under different climatic regimes if, for example, the dispersal of core populations or the rate of extinction of satellite populations is a function of fish density.

Conservative standards of salmon protection may be necessary even during periods of high productivity to maintain the genetic slack needed to withstand subsequent productivity troughs. Habitat fragmentation and loss of local stocks will likely magnify the effects of productivity troughs by also increasing freshwater mortality, inhibiting recolonization of disturbed habitats, and slowing rates of population recovery. Thus, in concert with large-scale changes in climate, increases in the rates of local extinction and loss of stock diversity may lead to greater synchrony in the dynamics of salmon populations. Regional patterns of salmon decline in the Columbia Basin and throughout much of the Pacific Northwest are generally consistent with this synchronization hypothesis.

Management Needs:

1. Determine the effects of ocean conditions on anadromous fish populations.
2. Evaluate or adjust inland actions in response to ocean conditions.
3. Determine if hatchery production should be scaled back during periods of low ocean productivity in order to minimize competition in the estuary or marine environments?

Critical Uncertainties:

1. Lack of long-term monitoring of ocean conditions and the factors influencing survival of salmon during their first weeks or months at sea severely limit understanding of the specific causes of inter-decadal fluctuations in salmon production.

2. Stock-specific distributions of Columbia Basin salmon in the ocean and the migratory patterns of hatchery versus wild salmon are poorly understood. It is important to know whether hatchery practices affect the migratory patterns and potential marine survival of salmon.

3. There is increasing evidence worldwide that ocean fisheries can have a destabilizing influence on marine food chains. Harvest management programs based on stock recruitment relationships and monitoring of individual species do not provide adequate indicators of the effects of harvest activities on ocean food webs.

The Council's Research Recommendations:

8.1 Determine how different species migrate and utilize the ocean environment.

8.2 Determine the relative effects of the ocean on different fish stocks compared to the effects

of inland actions.

8.3 Integrate research on the effects of ocean conditions on productivity of salmon with estuarine and riverine research.

Emerging Issues

Impacts of Climate Change on Fish and Wildlife Restoration

Overview: The potential impacts of global climate change are recognized at national and international levels. In addition, the impacts of short and longer-term climate variation and ocean conditions are now recognized as major contributors to fluctuations and trends in salmon abundance coast-wide. While a widely recognized phenomenon, the impacts of climate change are rarely incorporated into natural resource planning. The ISAB noted that the Council's program and the NOAA Fisheries recovery strategies do not consider the impacts of climate change and implicitly assume a level base case. However, the changes in regional snowpack and stream flows in the Columbia Basin projected by many climate models could have a profound impact on the success of restoration efforts and the status of fish and wildlife populations. The cumulative effects of human disturbance may not become apparent until severe climatic stresses trigger a dramatic response. Such interactions may be particularly severe in the Pacific Northwest where periods of reduced ocean survival of salmon and periods of stressful freshwater conditions (due to reduced precipitation, low stream flow, and increased stream temperatures) tend to be concurrent.

The Council has asked the ISAB to conduct a review of the potential impacts of climate change on the success and direction of the Council's fish and wildlife program. The ISAB is to review projections of climate change and synthesize the current scientific understanding of climate trends in the Pacific Northwest and how these affect biologically important parameters such as marine conditions, stream flow, temperatures, and species ranges. The ISAB will focus on how these trends could impact the success of restoration efforts and suggest how consideration of these trends might impact the direction of the Council's program and how the region should incorporate knowledge of climate trends in fish and wildlife planning and management.

The Council requested that the climate change review address two distinct areas of concern, the ocean environment and the freshwater environment. The ISAB has proposed to bifurcate the review and first address the effect of climate variability on the ocean environment. As previously stated, the ISAB intends to complete this analysis as part of the harvest review. This approach should allow the ISAB to explore the relationship between varying ocean regimes, hatchery production, and harvest rates. In addition, the ISAB will address the Council's question of how climate change may affect the frequency of short-term variation in oceanic conditions such as El Nino events as well as longer-term overall marine productivity. Short and medium cyclic climate variations, as well as longer trends, are likely to impact choices for restoration and preservation of fish and wildlife habitats under the Council's program.
With regard to the freshwater environment, the ISAB's Tributary Habitat Report (Council Document ISAB-2003-2) considered climate change, but did not explicitly address it. The ISAB believes a more complete review is warranted of the potential impact of climate change on the freshwater environment including changes to snowpack, stream flow, and species distribution. The ISAB intends to fully undertake the freshwater component of the review after completing

the harvest review. The ISAB will focus on describing the potential scale of the impacts of climate change on the success of restoration efforts and how the uncertainty of impacts could be incorporated into fish and wildlife planning and management. The review should be useful in informing future program amendments and recovery planning.

Management Needs:

1. Determine how climate trends in the Pacific Northwest affect biologically important parameters such as marine conditions, stream flow, temperatures, and species ranges?

Critical Uncertainties: The risks of global warming are potentially great for Columbia Basin salmon due to the sensitivity of southern salmon stocks to climate-related shifts in the position of the sub-arctic boundary, the strength of the California Current, the intensity of coastal upwelling, and the frequency and intensity of El Niño events. While the potential effects of global warming on ocean circulation patterns are poorly understood, the implications for salmon restoration efforts throughout the Pacific Northwest are significant.

The Council's Research Recommendations:
This section will be updated based on the ISAB Harvest Management review will be completed in January 2004.

Toxics

Overview: Eco-toxicology is an emerging research area, as there is a lack of understanding about how contaminants may affect the survival and recovery of listed species, as well as people and the ecosystem. For example, in the 1950s the only acknowledged harmful impact of runoff from urban areas was flooding. The solution was to build conveyance systems to get water off the land. In the 1970s it was decided that the impact of runoff on channels warranted expensive channel armoring and detention ponds sized to reduce flow velocity in channels. In the 1980s it was learned that the sizes of ponds were still too small to prevent erosion. In the 1990s it was learned that dramatic declines in aquatic life and especially anadromous fish resulted from urban runoff.

Today, a major issue is the lack of a "relative risk model" to extrapolate potential contaminant risk to salmon in the majority of areas where there are few or no data. (This topic will be discussed in a workshop sponsored by EPA and NOAA Fisheries and hosted by the Council in spring of 2004.) The inability make even a qualitative assessment of risk from contaminants basically anywhere in the Pacific Northwest is a major gap in our understanding that contributes to gaps in management.

Environmental contaminants such as trace elements (including heavy metals), pesticides, petroleum, and related petrochemical compounds pose a substantial threat to some aquatic ecosystems. Fish are vulnerable in rivers and lakes draining watersheds that support irrigated agriculture, mining, fossil fuel power generation, large municipal/industrial complexes, and other concentrated sources of human-caused activities. Managers require contaminant surveys and bio-monitoring to detect the occurrence and bioaccumulation of suspected contaminants. Studies are also needed in aquatic eco-toxicology to detect and quantify fate and effects in the environment.

Endocrine disrupters are a particularly significant issue requiring basic research, currently undertaken by the Western Fisheries Research Center of the U.S. Geologic Survey. Chemical processes are critical determinants of habitat quality for salmonids, and they should be explicitly addressed at the outset of any restoration. In Seattle, adult coho salmon have perished when they came back to spawn in small urban streams. Many millions of dollars were spent to restore "habitat" in these systems, with a near-exclusive focus on physical processes. Longfellow Creek in West Seattle is a regional model for stream restoration, and yet almost 90-percent adult pre-spawn mortality occurred in the 2002 coho run, apparently as a result of degraded water quality.

It is important to integrate chemical processes into the "habitat" perspective, especially for agricultural and urban watersheds. Otherwise, restoration projects will continue to make the landscape appear restored, without addressing the health of the underlying ecosystem. The urban stream problem should be viewed as a case study in salmon habitat restoration.

Management Needs:

1. Determine the extent of toxic contaminants in fish in the Columbia River Basin.

2. Determine how these contaminants affect fish survival and productivity.

3. Juvenile outmigrant Chinook salmon are accumulating appreciable levels of toxic contaminants before they leave the Lower Columbia River estuary, and the levels are among the highest seen in any populations examined to date by the U.S. Environmental Protection Agency along the Oregon and Washington coasts. Part of this contamination comes from hatchery feeds and from bio-accumulative contaminants such as polychlorinated biphenyls and the DDT, but it also is known that salmon are exposed via contaminated prey items in the Lower Columbia River. Other contaminants, though not bio-accumulative in fish, are still toxic, and salmon collected at the confluence of the Willamette and Columbia rivers show evidence such exposure as well.

Critical Uncertainties:

1. The sources and fluxes of contaminants in the Lower Columbia River estuary have not been characterized. Little information exists as to how salmon and other species are being exposed, such as the relative contributions from upstream sources versus lower river off-channel sources versus hatchery feeds.

2. Little information exists on contaminant body burdens in hatchery fish versus wild listed stocks. Wild fish will not have the extra exposure from feed that is seen in hatchery fish, but wild fish also may remain in the estuary longer and accordingly have more potential to take up contaminants from the environment. It is known that off-channel habitats, where wild juvenile salmon tend to be found, are the areas with comparatively higher levels of chemical contaminants in sediment and presumably prey.

3. The biological consequences of the current levels of exposure are unknown, but body burdens of polychlorinated biphenyls are near levels of concern and fish are exposed to multiple

contaminants.

4. Because of the critical nature of estuary use for several populations of Pacific salmon with different life histories, toxic contaminant exposure poses a significant uncertainty in considering recovery efforts for Columbia River stocks.

The Council's Research Recommendations:

9.1 Determine how to develop a research, monitoring and evaluation program for chemical habitat.

9.2 Determine how to identify and quantify sources of toxic contaminants in the Lower Columbia River.

9.3 Determine the biological consequences of contaminant exposure in salmon, as well as consequences for other species, notably prey species and higher trophic levels, such as piscivorous birds.

9.4 Determine the exposure patterns of wild versus hatchery fish, in populations with different life histories and patterns of estuary use, in various listed ESUs.

9.5 Determine whether contaminant transport in suspended particulates contributes to contaminant uptake in fish. Contaminant monitoring and research should be conducted as part of overall investigations of chemical habitat quality, including studies of organic carbon transport and cycling.

9.6 Determine the cause and effects of disease, tumors, and other abnormalities of fish on the population dynamics of the fish and the implications for ecosystem and human health.

9.7 Determine potential nontarget impacts of management techniques, such as sub-lethal impacts of herbicides on salmonids.

9.8 What alternative pesticides that can be used for the eradication of specific aquatic nuisance species?

9.9 Evaluate bioaccumulation of toxins and heavy metals in native fishes.

Invasive Species

Overview: Invasive species comprise one of the most significant alterations of native ecosystems for fish and wildlife, and plants. Research is therefore needed regarding interactions between native and invasive species, including predators, prey, food chain organisms, and those that alter habitat structure; how competitors respond to altered systems and to restoration and recovery actions; and how food supplies have been altered and how they can be restored (CENR, 2000).

It is important to note the distinction that exists between an invasive species and a non-native that is the result of a management decision. An example of a non-native fish species potentially impacting anadromous stocks is American shad. In addition to shad, there are a number of other introduced and exotic species present in the Columbia River Basin Ecosystem that we know very little about. Some of these species include: channel catfish, yellow perch, bluegill/other sunfish, crappies, Eurasian milfoil, Asiatic clams (*Corbicula manilensis*), and others. All of these species

have an impact on juvenile salmonids, either directly (as predators) or indirectly (by altering the food base). As these species continue to become more dominant in the ecosystem they will have a greater impact on salmon populations. Once established, ANS can permanently alter habitat supporting native aquatic species. Research should be initiated as soon as possible to understand the significance of these impacts. Offsite projects, particularly lake rehabilitation, have been successful in removing hybridized fish populations, creating genetic reserves for native fish, drastically improving fisheries, and eliminating source populations for further illegal introductions. The Corps should be alert to regional decisions, including Council decisions, that might bear on passage or survival issues at the dams.

Management Needs:

1. Determine the extent that invasive species affect fish and wildlife in the Columbia River basin.

2. Determine the extent that shad negatively impact anadromous fish.

3. Determine the economic consequences of invasions, such as the effect of *Hydrilla* on native species, recreation, lakefront property values, and power generation.

4. Determine what environmental manipulations can be accomplished in an environmentally sensitive manner to reduce likelihood of establishment or inhibit growth and dispersal of invasive populations?

Critical Uncertainties: Habitat restoration may be ineffective at restoring native species where introduced non-native species are well established. Available science suggests that non-natives can be effectively suppressed where habitats are maintained by a natural range of flow and temperature variation. However, abrupt changes in reservoir management could temporarily drive existing populations of some non-native fishes into tributary habitats, increasing the risk of their colonization of tributaries. Conversely, reservoir changes also will likely create new mainstem habitat refugia for native fishes. The risk of dispersal and establishment of non-native fishes will be lowest where tributaries retain relatively natural streamflows, thermal regimes, habitat diversity, and intact native fish assemblages.

The Council's Research Recommendations:

10.1 Determine the impact of non-indigenous (exotic) aquatic and terrestrial species on salmonid recovery.

10.2 Determine the environmental constraints on abundance and distribution of currently established or eminently threatening species.

10.3 Determine the ecological consequences of invasions (competition, predation, and cascading trophic effects on native species, nutrient cycling, effect of management activities).

10.4 Determine how low-density populations of invasive species can be detected (new monitoring techniques and optimized search protocols).

10.5 Develop rapid response methodologies to eliminate newly introduced species at the source of introduction before they spread and become unmanageable in the environment.

10.6 Determine how presently accepted non-indigenous species (warm-water fish) can be

managed to minimize ecological effects.

10.7 Develop and research effective biological control agents to treat exotic invasive infestations.

Impact of Human Development Patterns on Fish and Wildlife Restoration

Overview: Like climate change, the impact of an increasing human population in the Columbia Basin is a widely recognized issue but one that is rarely incorporated into fish and wildlife planning. Human population of the Columbia Basin is increasing rapidly, a trend that is expected to continue. This increase is not occurring uniformly across the basin, but is largely concentrated in and around urban areas and contributes to specific impacts such as toxics. The increased population will potentially impact non-urban areas as well through increased recreation and housing in riparian and rural areas. At the same time, the economy of the region is shifting with the potential for both positive and negative impacts on fish and wildlife habitats. The ISAB has pointed out that the Council's program and the NOAA Fisheries restoration plans do not include consideration of these trends but, as with climate change, assume a level base case. Because the Council's fish and wildlife program mitigates human impacts on fish and wildlife habitats, it is important to consider human demographic trends and their potential impact on fish and wildlife habitats. In April 2002, the Council asked the ISAB to provide an analysis of the projected trends and patterns in human population growth patterns in the Columbia Basin and how these might affect the success and direction of the Council's program.

Management Needs: The ISAB should review information on population projections and patterns of human population increases across the landscape. The review should discuss how these changes might affect fish and wildlife habitats and address how projected changes in economic patterns might moderate or exacerbate these impacts. Finally the ISAB should suggest how human demographic changes could be effectively incorporated into fish and wildlife planning. The ISAB should be clear that the Council is not asking for recommendations or conclusions on the need for changes in land use laws or other social aspects not associated with the development of subbasin plans and the Council's program. The ISAB may conduct a review of population growth at a future date.

II. Charting A Course for the Future: Identifying Research Priorities

This chapter summarizes current research projects under the fish and wildlife program, compares these projects with the recommendations for future research set forth in Chapter I, and identifies remaining gaps in knowledge.

Allocation of Program Versus Research Expenditures

The Northwest Power Act establishes Bonneville's obligation to fully mitigate for fish and wildlife impacts from the development and operation of the hydropower system. The Council recognizes its obligation, in turn, to develop a program that guides Bonneville's mitigation efforts and is staged to accommodate yearly budget limitations. The Council has adopted the following funding principles to prioritize among the many needs to address impacts to fish and wildlife throughout the basin:

- The Bonneville Power Administration will fulfill its Fish and Wildlife Funding Principles (September 16, 1998) including the commitment to "meet all of its fish and wildlife obligations."
- The determination of provincial budget levels should take into account the level of impact caused by the federally operated hydropower system. Other factors will also influence this determination including opportunities for off-site mitigation.
- Wildlife mitigation should emphasize addressing areas of the basin with the highest proportion of unmitigated losses.

Table 1 (page 3) portrays the current distribution of research funding in the fish and wildlife program under Bonneville's "direct funded" category. All of the funding for a project is assigned to the primary topic, even for projects addressing multiple topics. A future phase of analysis could achieve greater precision of funding by specifying amounts for each research objective within a project and more closely examining the connections between current projects and the research recommendations. Assessment of the relevance of on-going project objectives to the research recommendations identified in this plan should be made after this plan is finalized.

The current allocation of funds targeting research indicates that two topics dominate expenditures under the research agenda, hatchery effectiveness at $30.1 million and habitat at $13.6 million. The Council is maintaining this allocation until a new budget allocation is adopted. Thus, the Fish and Wildlife Program includes a general allocation of expenditures to guide the overall program by resource category, but not a dedicated allocation to guide research. In addition the Council has not yet developed additional guidance on the allocation of funds by research topic, some of which are unique to a single resource category (topic of ocean productivity and category of anadromous fish), while others, such as monitoring and evaluation, are relevant to anadromous fish, resident fish, and wildlife.

Comparison of Current Council Research with Recommendations for Future Research

Chapter I identified specific recommendations by research topic. Tables 1 and 2 describe the number of projects and costs associated with on-going research by these topics under the direct funded and reimbursable programs, respectively. The relationship between research that is recommended and that which is on going is summarized in Table 3. Table 3 shows in a general way the extent to which research recommendations are being addressed by current projects and, thereby gaps in coverage. It natural for these gaps to exist considering that this is the first effort to compile a list of research recommendations for the region and that the current pool of research projects developed over a long period of time in response to: long-standing objectives of the Council's Fish and Wildlife Program; Provincial Review project solicitations; and the requirements of the federal biological opinions and other planning documents.

Table 3. Research Recommendations and Coverage of Recommendations by Fish and wildlife Program and Army Corps of Engineers and Bonneville Projects

Research Topic and Number of Research Recommendations in Parenthesis	Number of Research Recommendations Currently or Previously Implemented by the Council's Program	Number of Research Recommendations Partially Implemented by the Council's Program	Number of Research Recommendations Currently or Previously Funded by the COE/BPA	Number of Research Recommendations Partially Implemented by the COE/BPA	Total Number of Research Recommendations Implemented in Whole or in Part
Hatchery Effectiveness (7)	4	0	5	1	10
Hydropower (21)	1	0	12	3	16
Habitat (23)	8	2	1	0	11
Recovery Planning (13)	0	0	0	0	0
Monitoring/ Evaluation (17)	7	7	10	0	24
Harvest Management (4)	0	0	0	0	0
Estuary (16)	10	1	3	0	14
Natural Variation and Ocean Productivity (3)	1	0	0	0	1
Toxics (9)	0	1	0	0	1
Invasive species (7)	0	2	0	0	2
Total 120	31	13	31	4	Total 79

The results in Table 3 were derived from an evaluation of each research recommendation identified in Chapter I, as "covered, partially covered, or not covered" by the fish and wildlife program or the projects of the Army Corps of Engineers or Bonneville. Please note that neither the number of current projects, nor the amount allocated to a given topic in Tables 1 and 2, is indicative of whether research questions relevant to the recommendations set forth in Chapter I

are being asked or answered. The purpose of Table 3 is simply to convey a sense of current fish and wildlife program coverage of the compiled research recommendations. The last column in Table 3 reports the total number of research recommendations fully or partially implemented by on-going or recent projects. For the topics of hatchery effectiveness, and for monitoring and evaluation, some recommendations are being implemented by more than one project. More importantly, please note that some research topics have no associated research activity, and therefore constitute "gaps." Thus, Tables 1 and 2 portrayed current activity, while Table 3 identifies gaps in knowledge that need to be addressed.

Yet Table 3 also indicates that many of the research recommendation set forth in Chapter I are already being addressed by current or recent projects. The fact that many of the research recommendations are already being addressed explains why the number and/or salience of those that remain may appear unexpectedly low for some research topics. Yet the apparently high degree of project coverage for some research topics by itself does not mean that the hard work has been completed. More realistically, it means the existing projects provide a strong start on a research program. Future analysis could more closely examine the connections between current projects and research recommendations and identify opportunities for existing projects to address the remaining gaps.

Identifying Priorities for Future Research

> *Science is subject to the common tendency to add knowledge about already well-defined topics instead of seeking entirely new approaches and concepts. While incremental gains in understanding recognized problems are certainly necessary and it is appropriate to use science to support and refine existing management options, its value as a means to identify and test new options should not be overlooked. Research directed at further incremental gains in familiar subject areas must be balanced by research to close the many knowledge gaps.* (Emphasis added.)
>
> -- Committee on the Environment and Natural Resources, 2000

ISRP reviews have highlighted the need for a basinwide research plan that would help close these knowledge gaps by evaluating whether on-going research is salient, identifying needed shifts in emphasis, and identifying emerging research topics. The ISRP recommended that the research plan address overarching questions and assist in making decisions about the relative importance among projects by providing a prioritization for future research. Closing key gaps in knowledge was the priority for the research plan identified by the Council's independent science groups at their workshop, and the Committee on the Environment and Natural Resources in their 2000 report.

To implement this recommendation, the draft research plan proposes to address knowledge gaps in the following way. A "gap in knowledge" is considered to exist whenever a research recommendation set forth in Chapter I is not being implemented or addressed by a research project under the Fish and Wildlife Program. The research recommendations that remain unaddressed are considered to be research priorities. This analysis was conducted by staff, and would be revised as part of the review of the research plan by the Council, ISAB and ISRP, fish

and wildlife managers, and others. The significance of the remaining gaps is a management and policy issue.

The research recommendation and critical uncertainties identified in the preceding section are sufficient to guide implementation of the research plan action at a programmatic scale, such as by informing the selection of specific research recommendations for requests for proposals. Implementation of the plan at the project scale will occur through ISRP review and the future project selection process. During this phase of implementation the technical feasibility and cost-effectiveness of individual projects will be considered as factors in the review process. The Council, as necessary, may also respond to rapidly emerging management uncertainties by identifying additional research priorities.

Balancing Curative and Preventative Approaches to Restoration

Today the fish and wildlife program is in a transition period. After 20 years of implementing a broad-based program for restoring anadromous fish, resident fish, and wildlife, the Council is now reconfiguring the program to address new responsibilities under the Endangered Species Act (ESA). In order to successfully address these new and more specific responsibilities under the ESA, this draft research plan provides specific guidance for research.

The Council emphasizes a balanced approach to implementing the fish and wildlife program, despite strong external pressures to shift the entire program into an ESA implementation mode. Shifting program emphasis too far in the direction of the ESA could become self-defeating, as the curative approach embodied in the ESA is expensive and the outcomes are uncertain. In contrast, the fish and wildlife program embodies the preventative approach of protecting the viability of all affected species to preclude additional listings under the ESA. The preventative approach is less expensive and more likely to protect existing fish and wildlife. The Council must strike a balance between these two approaches, even while moving beyond the status quo. From a policy perspective, the Council has an interest in emphasizing research in the following areas:

1. Mainstem operations including spill, flow augmentation and fish transportation.

2. Rearing and spawning habitat, particularly quantification of benefits from riparian protection, improved screening and increased seasonal water flows.

3. Estuary and near shore ocean habitats.

4. Evaluation of new approaches to harvest, such as selective harvest technology.

Integrating Research Results into Council Policy and Decision-making

The integration of scientific knowledge into management decision-making is a challenging task for public officials, planners, and environmental lawmakers. This integration is central to adaptive management, a concept that provides a framework for managers to launch the implementation of policies despite uncertainty, variability, and potential risks. At the core of this

approach is a deliberate plan to learn from decisions and progressively fill knowledge gaps. This way, management actions, whether successful or not, provide valuable information to improve our understanding of program effectiveness and influence future management decisions in subsequent iterations of the research cycle.

Adaptive Management

In practice, adaptive management is a method for taking action in the absence of information, or when only limited information is available. This may occur when the information is so unique that it does not exist; there is no basis in prior experience from which to extrapolate; or, when prior experience occurred at such a different scale as to be irrelevant. Adaptive management provides a valuable tool for ensuring that timely feedback from such diverse activities informs the re-direction of future research to increase effectiveness. In their seminal work applying adaptive management in a hydropower context, Professor Kai Lee and the late Jody Lawrence wrote:

> *Adaptive management is learning by doing... Adaptive management is both a conceptual approach and a strategy for implementation. As a conceptual approach, it sets a scientifically sound course that does not make action dependent on extensive studies. As a strategy for implementation, adaptive management provides a framework within which measures can be evaluated systematically as they are carried out. Adaptive management encourages deliberate design of measures. This assures that both success and failures are detected early and interpreted properly as guidance for future action. Information from these evaluations should enable planners to estimate the effectiveness of protection and enhancement measures on a systemwide basis. Measures should be formulated as hypotheses. Measures should make an observable difference. Monitoring must be designed at the outset. Biological confirmation is the fundamental measure of effectiveness*. (Emphasis added.)

(From *Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, Environmental Law Vol.16:431-460, 1986.)

The National Research Council (NRC) related several lessons learned about the practicability of adaptive management and the institutional conditions that affect how experiments on the scale of an ecosystem can be conducted (NRC 1996). These lessons are:

1. Learning takes from decades to as long as a century. Patience is both necessary and difficult, particularly in institutional settings such as government that work in faster cycles.

2. Systematic record keeping and monitoring are essential if learning is to be possible. But collecting information is expensive and often hard to justify at the outset and during times of budget stringency because the benefits of learning are hard to estimate quantitatively.

3. Cooperative management in the design and execution of experiments is indispensable. Experimentation within the context of resource use depends on the collaboration of resource users.

4. Adaptive management does not eliminate political conflict but can affect its character in important, if indirect, ways.

It is important to note that the NRC found that, paradoxically, each of these lessons runs counter to, or at cross-purposes with, the administrative framework of the ESA. This disconnection is the source of several factors confounding activity in the planning arena. One example is that the current approach to recovery planning for salmonids relies heavily on offsite habitat mitigation to generate increases in productivity. It may well be that habitat can meet this expectation, yet habitat restoration has historically been an underutilized "H," and will require the longest timeline to quantify the benefits conferred by a projects in terms of increases in life stage productivity.

Further, it remains to be seen whether experimental research on monitoring and evaluation will in fact generate a basis for quantitatively establishing causal linkage between benefits conferred at the project site yielding increases in life-stage productivity. The quest for biological confirmation, through the monitoring and detection of increases in life-stage productivity, is a central tenet of the 2000 FCRPS Biological Opinion.

In sum, significant planning challenges arise from the disconnection between the quest for legal certainty and what are considered acceptable levels of scientific uncertainty. There is an expectation within legal proceedings that the certainty of science be absolute. Yet legal rules, such as the Federal Rules of Civil Procedure, have exceptions, and exceptions to the exceptions. In the legal arena, arguments are based on differing and competing applications of the rules to interpret facts. In the science arena, hypotheses are used to test what the facts are. Despite these difficulties, an important alignment of interest groups was achieved through the protracted negotiations that culminated in the Basinwide Recovery Plan (All-H Paper) and the derivative FCRPS Biological Opinion. Recognizing that it took five years to negotiate this approach to recovery, this plan acknowledges the importance of implementing the All-H approach long enough to constitute a fair test.

Evaluating the Council's Research Program

An inaugural workshop of the Council's three independent science groups was held in 2003 to consider progress on a regional research plan. The primary topics of discussion were critical uncertainties and research needs, and the findings of the workshop are reflected in Chapter I. This plan proposes that workshops of the independent science groups be held as needed, but in advance of future project selection processes. The evaluation of the research plan should be a standing agenda item. These workshops can provide an evaluation of progress, or lack of progress, on research issues significant to fish and wildlife in the Columbia River Basin. Science group workshops present an opportunity for:

1. Discussion among the science groups of the ISRP's Retrospective Review;

2. Evaluation of progress toward answering the research questions in the plan;

3. Highlighting research accomplishments; and,

4. Updating the plan with new research questions and priorities.

Workshops can provide a forum for moving forward, as well as looking back. In between the workshops, the results of individual research projects can provide a basis for larger-scale reviews of the effectiveness of the research program and discussion of additional complementary approaches, including:

- Broader scale analysis that applies information from several projects to address a particular question.

- Synthesis reports of work completed in a particular area, such as the Giorgi report, *Mainstem Passage Strategies in the Columbia River System: Transportation, Spill, and Flow Augmentation* (Council Document 2002-3).

- Expanded provincial review presentations.

- Workshops structured around single topics driven by critical questions, such as transportation effects, and projects synthesized to address that topic.

- Workshops and symposia on emerging topics, such as toxics, are a good way to shift to a preventative mode of operation.

Another mechanism for evaluating and re-directing the implementation of the research plan should be the convocation of ion Workshops to address emerging or previously unanticipated research issues as needed. These workshops will help assess future research topics through oral presentations by authorities on the topic, development of initial hypotheses by participants, reporting of results of relevant studies, evaluation of the potential contribution to the regional body of knowledge, and assessment of the ease or difficulty of implementing research results into management actions. The workshops will promote the free flow of scientific information and provide the Council with a credible basis for funding decisions.

III. Developing and Implementing a Regional Research Agenda

Institutional Arrangements

> *Historically, science has played two different roles in salmon management. The first, a technical leadership role, has involved establishing the fundamental relationship between salmon and their environment that collectively forms the basis for management decisions. The second, a "sustaining," has involved selectively seeking data and analyses to support regulatory actions or policy decisions by agencies, tribes, or other organizations. Ideally, science focuses on the more objective first role, but in fact, salmon management has been dominated by the second.*
>
> -- Committee on the Environment and Natural Resources, 2000

Acknowledgement of the dominance of the "sustaining" role of science in the Columbia River Basin is an essential element of any assessment of where restoration and recovery efforts stand today. This recognition does not impugn the quality of the science conducted in the basin, but it does help explain why in some cases work of apparently low relevance is continued, while in other cases the application of results of high relevance remains a promise unfulfilled. Further, it explains disparities in the availability of data to support various management alternatives. A common manifestation of this phenomenon is that insufficient information will be available on politically controversial management alternatives.

In the selection of new research projects, agencies understandably tend not to fund studies that seem to have limited usefulness for supporting current management practices, or that might produce results that actually contradict current practice. Thus, the scientific basis for making management decisions is skewed by the propensity of institutional funding sources to support non-controversial research on an almost indefinite basis, thus supporting repetitive research that generates diminishing data returns. Despite the systemic nature of some of these impediments, they can be overcome by a combination of conscious effort and alternative approaches.

In 1996 the National Research Council stated that current institutional arrangements in the Pacific Northwest have contributed to the salmon problem and probably will need modification if the problem is to be solved and that an understanding of how to include "good science" as part of the institutional arrangement is important (NRC, 1996). The NRC recommended that the adoption of a coordinated, interagency approach to new scientific efforts could help reduce the tendency to fund research in areas of past agency investment.

Cooperative Research: Building a Regional Research Partnership

> *A great deal is known about the requirements of salmon, yet much remains unknown, and some gaps in knowledge are crucial to a long-term, stable solution to the salmon problem. Enough is known in the short term to improve the prospects of salmon if knowledge is applied wisely and quickly, but not enough information is known to warrant confidence in a long-term regional plan for salmon....the components of the salmon problem are so diverse that no one person can know all that needs to be known for a*

comprehensive solution. Thus, the salmon problem is in a sense a cognitive problem whose solution will depend on close cooperation and collaboration of people with many kinds of experience and expertise. (Emphasis added.)

-- National Research Council, 1996

Although the Northwest Power Act process falls short of the ideal of "power-sharing in the exercise of resource management" (Pinkerton, 1992), it did merge the inherent conflicts of fish and wildlife mitigation and hydropower production in a way that forced conflicts into the open and fostered joint action. Further, the framework established by the Northwest Power Act has been characterized as the largest attempt to cooperatively manage power and fish and wildlife (Lee et al. 1980). The NRC found that cooperative management implies an institutional change or shift in the structure of decision-making that acknowledges the role of various interests, such as consumers, representatives of different industries, and environmentalists, in the areas of policy, planning, implementation, and evaluation.

The region lacks a regional decision making forum that can arbitrate between competing initiatives to implement the All-H approach. Therefore a forum should be convened where researchers can cross-disciplinary and institutional boundaries and find peer support for potentially controversial recommendations. A key challenge for such a research partnership is to move beyond the piece-meal solutions that may have undercut the overall success of past restoration efforts. The fish and wildlife scientists and managers in the region could accomplish this by cooperatively designing a research initiative to address the critical uncertainties regarding fish and wildlife restoration, for example mortality across the life cycle of the salmon.

Recommendation: Policy makers such as the Council members and regional executives should foster cooperation of the currently compartmentalized research agendas and budgets of entities that share common objectives, by convening an informal forum to provide a point of interface for research program leads, such as a research consortium or partnership.

In the past, attempts have been made to convene executive level multi-agency groups and fora for the purpose of coordinating resource management decision-making across the Columbia River Basin. These unsuccessful efforts indicate that it may not be possible to convene a single "super-group" that can address management decisions across all subject matter areas of resource management in the Columbia River Basin. This is in part due to significant differences between programs in their missions, structures, proposal development, and proposal review processes. Consequently, this plan simply recommends the convocation of a partnership to foster collaborative research. A research partnership could endeavor to transcend the institutional impediments described in the section on adaptive management.

Recommendation: A research partnership should be convened to provide a forum for the identification of shared research priorities and development of collaborative implementation strategies.

Many of the resource management entities contacted during the development of this research plan expressed support for this concept. The Council could convene and initially host a regional

research partnership, as the 2000 Fish and Wildlife Program states that a meeting of fish and wildlife agencies, tribes and hydrosystem operating agencies should be convened regularly to identify key uncertainties about the operation of the hydrosystem and associated mainstem mitigation activities.

Yet in order to succeed, a collaborative regional research initiative would require support in two key areas; monitoring and evaluation, and data management. The research partnership could draw support on monitoring issues from the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), charted in 2004 to coordinate a regional approach to monitoring. The mission of PNAMP is to coordinate existing monitoring programs in an effort to develop the feedback mechanism that is missing at the programmatic scale. The Northwest Environmental Data Network is an initiative to deploy a regional data standards program to support regional data networking. The development of a regional data management partnership is a concept for which Council sponsored projects and support have already provided significant substance.

If such a configuration of partnerships were to coordinate their respective efforts, the research partnership could increase the ability of the region to reduce scientific uncertainty; the monitoring partnership could support the evaluation that has long been missing from the Columbia River Basin; and the data partnership could support a data repository for analytical manipulation at different scales. Even if these partnerships are only semi-formal in an administrative sense, and only loosely coupled in a decision-making sense, the synergy that would result from linking research, monitoring and evaluation, and data management would significantly increase the ability of the region to re-direct its efforts based on the cumulative results of work at the project scale.

Implementing Research Recommendations: Opportunities for Collaboration

> *Basic scientific information is lacking for many of the remedial actions that must be taken over a longer term.*
>
> -- Committee on the Environment and Natural Resources, 2000

Hatchery Effectiveness

There is an urgent need for fundamental information on the interactions of hatchery-produced fish with wild populations (Return to the River, 1996; CENR, 2000). Effects of hatchery-produced fish on wild stocks potentially include genetic alteration, competition, predation, and disease. The fish and wildlife program should include mechanisms to ensure that supplementation projects are collecting the data necessary to test their effectiveness. Project analysis and reporting should be required.

Current monitoring and evaluation efforts are inadequate to estimate either benefit or harm from ongoing supplementation projects. It is imperative that requisite reference populations be established and that adequate levels of monitoring and evaluation be included as part of the basinwide adaptive management experiment. Specifically, multiple supplementation projects should be coordinated across the Columbia River Basin so that in aggregate they constitute a

basinwide adaptive management experiment, maximizing the information collected and attempting to reduce uncertainty. Future investment should be in establishing robust experiments with un-supplemented reference streams and rigorous monitoring.

Sufficient attention must be given to evaluating ecological interactions, so that it will be possible to determine whether the intrinsic biological attributes of the species being supplemented, biotic interactions, or habitat limitations constrained the anticipated increases in natural-origin adult recruits. Many hypotheses and conjectures concerning supplementation are largely unevaluated.

Recommendation: Determine the diversity of life history types and species that need to be maintained in order to sustain a system of populations in the face of environmental variation.

Hydrosystem

The Council has proposed increasing the priority of research on the migration corridor. If the Council plan for the mainstem is to provide the best benefit for fish migration, it must have better estimates of the magnitude of the benefits from spill, flow augmentation, and fish barging. The new research questions introduced for the mainstem should guide these additional expenditures.

Anadromous Fish Evaluation Program

The U. S. Army Corps of Engineers, Northwestern Division, has sponsored biological studies continuously since 1952 in an integrated, applied research program to better understand and improve anadromous fish passage conditions at its multi-purpose projects on the Columbia and lower Snake Rivers, in Oregon and Washington. These research, monitoring, and evaluation studies are managed under the Anadromous Fish Evaluation Program (AFEP). The AFEP is the process that coordinates the Corps' fish program with federal, state, and tribal fish and wildlife agencies that provide both technical and policy level input to the Corps on study objectives, experimental design, and methodologies. (A few AFEP studies are funded from project operations and maintenance accounts as well.)

The main purpose of the AFEP is to produce scientific information to assist the Corps in making engineering, design, and operations decisions for the eight main-stem Columbia and Snake river projects to provide fish with safe, efficient passage through the mainstem migration corridor. Each project (dam) has multiple authorized purposes and uses, including migratory fish passage; and is affected by several environmental and project operating statutes. These include the ESA, Clean Water Act, National Environmental Policy Act, Northwest Power Act, and the Fish and Wildlife Coordination Act. At the current time, ESA guidelines for protection of listed salmon, steelhead, and white sturgeon species are contained in biological opinions prepared by NOAA Fisheries and U.S. Fish and Wildlife Service (USFWS), and strongly influence the Corps' fish program, including the AFEP. These biological opinions include measures to evaluate and make decisions on new and existing passage technologies and system configurations. The resulting biological studies have a high priority in the AFEP program. Most are conducted to facilitate system configuration decisions by answering key questions about behavior, survival, and condition of fish as they migrate through the mainstem corridor.

Most studies are integral components of elements of the Columbia River Fish Mitigation project, a large Corps construction account that funds numerous fish passage improvements at Columbia and Snake river mainstem dams. Research schedules are closely linked to those elements so that biological questions can be answered in a timely manner. Historically, Corps funded studies have focused primarily on project-specific adult and juvenile salmonid passage issues. However recently, estuarine, mechanism oriented, sturgeon and studies of juvenile and adult lamprey have been conducted as well. Most of the passage facilities and operations on the river have been developed and refined based on results of these studies. Passage issues include adult fish ladders and collection channels, juvenile bypasses with turbine intake screens, turbine passage, the juvenile fish transportation program, spill for juvenile fish passage, and a comprehensive set of project/hydrosystem operating criteria. Consequently, research studies evaluate passage success, survival, and fish condition for these technologies. Many research projects are related to new passage technologies, while some evaluate existing project features.

Based in part on the recommendations by the ISRP, the Corps is also working to develop a long-term strategic plan for its fish research program. A long-term plan currently exists for Bonneville Dam and is being developed for John Day and The Dalles dams. A document is also being developed to examine the major system improvements at McNary and the Lower Snake River Dams. This plan will be incorporated or referenced in more detail in this plan at a later date.

Short-Term Research Recommendations

1. Implement an experimental operation at Libby Dam that will limit the summer draft to 10 feet from full pool by the end of September. (NOAA could not say what effect it would have on outmigrating fish in the mainstem.)

2. Implement an experimental operation at Hungry Horse Dam that will limit the summer draft to 10 feet from full pool by the end of September. (NOAA could not say what effect it would have on outmigrating fish in the mainstem.)

3. If feasible, evaluate the biological effects on salmon survivals in the Lower Columbia River of possible flow augmentation from Libby and Hungry Horse dams. Design and implement new survival tests in the lower river to better understand the movement and survival of fall Chinook. (Council is convening a Symposium on Reservoir Operation/Flow Survival to address these first three issues.)

4. Studies directed at turbine improvements need to be undertaken in the context of other fish-protection approaches available in the basin and prioritized for budgeting according to their potential benefits to fish versus benefits to the power system.

Long-Term Research Recommendations

1. Continue the transportation study targeting Snake River fall Chinook. Evaluate relative success of transporting various groups of fall Chinook throughout the Snake River.

2. Implement actions to reduce the level of toxic contaminants in the Columbia and Snake river released from Corps facilities.

3. Determine habitat conditions in all of the mainstem reservoirs.

4. The AFEP lacks, but would benefit from, a strategic, multi-year research plan or framework. Strategic multi-year research plans with contingencies and alternative tests built in would make the program stronger by reducing time and resources spent annually. (Initiated in 2004.)

5. Strategic planning should be conducted by the Corps to identify where a more mechanism-oriented strategy (e.g. behavioral or mortality mechanisms) could yield benefits in research productivity, efficiency and economy of time and funds (and thus faster implementation of fish-protective features).

Habitat

Major long-term interventions will be required to restore the spawning and rearing sites, migratory corridors, and the spatial and temporal diversity of these habitats and to reconnect habitat types important for the continuity in the life cycles of salmon (CENR, 2000). In response to the recommendation of the independent science groups, the 2000 Fish and Wildlife Program places a greater importance on improved natural habitat for fish spawning and rearing throughout their life cycle, including estuary and marine stages.

Through subbasin planning a greater emphasis can be placed on the protection and restoration of habitat. This will require additional research to verify and measure the benefits from a wide variety of coordinated actions. For example, it will be important to measure the benefits from riparian protection, improved screening at water diversions, and increased seasonal flows. While we can assume such actions will be good for fish, there is little information about the magnitude of these benefits or how they may vary under different conditions.

Restoration of fish and wildlife will require restoration of ecological functions and processes to reestablish healthy watersheds. For example, there is a need for scientific research to define what functions of a riverine ecosystem must be restored for salmon and how to accomplish this restoration while maintaining the societal benefits of electricity production, navigation, flood control, irrigation, and recreation provided by dams.

Regarding mainstem habitat, an overview of current conditions needs to be developed and integrated into a coordinated plan for improving specific aspects of mainstem habitat. The mainstem habitat initiative is not focused on the mainstem habitat needs of the salmon and steelhead populations currently listed. Rather, it is a multispecies approach that recognizes that mitigation, enhancement, and rebuilding opportunities in the mainstem may have greater benefit for non-listed populations than to listed populations.

Short-Term Research Recommendations

1. Determine the importance of protecting mainstem habitat for recovery of bull trout.
2. Determine how to stabilize and improve burbot populations.

Long-Term Research Recommendations

1. Determine whether restoration of substantial mainstem habitat can be achieved by drawdown of selected reservoirs to expose and restore alluvial reaches, for example in the upper ends of John Day and McNary pools.

2. Determine whether free-flowing reaches downstream of hydroelectric dams can be regulated to achieve normative flow and temperature regimes thereby allowing the river to naturally restore instream and floodplain habitats and food webs.

3. Determine how to provide storage reservoirs with selective withdrawal systems to create a more normal annual temperature cycle in the rivers.

4. Conduct the necessary feasibility studies to restore anadromous fish to blocked areas.

Harvest Management

Harvest remains the primary reason for hatchery programs in the Columbia River Basin. This is especially true in the lower river, whereas the purpose of upper river programs appear more evenly divided between harvest and conservation. Yet the management of fisheries on mixed hatchery and wild stocks is believed to have contributed to the decline of natural production in the Columbia Basin. Because of declining natural production, those fisheries that still harvest Columbia River salmon are largely supported by hatcheries.

Hatcheries intended solely to produce fish for harvest may be used to create a replacement for the lost or diminished stocks. Hatcheries must be located and operated in a manner that does not lead to adverse effects on other stocks through excessive straying or excessive take of weak stocks in a mixed-stock fishery. The risks of detrimental effects of straying are a de-facto supplementation to naturally spawning populations are real, and likely far more serious than the risks involved in a well-designed supplementation program.

Short-Term Research Recommendations

1. Determine the relationship of salmon abundance to other components of the ecosystem that are connected by the life cycle of the salmon.

2. Ascertain whether sustained yield management of can be based on numerical spawning escapement goals at the watershed level.

Recovery Planning

The NOAA/USFWS Biological Opinions: What Research and Why?

On December 21, 2000, the federal government released the final version of a comprehensive, long-term strategy to restore threatened and endangered salmon and steelhead in the Columbia River Basin. This strategy outlined specific actions to be taken by the federal government and proposed additional actions for tribal, state and local governments, which together would prevent extinction of the 12 ESA-listed species and lead to their ultimate recovery. The biological goals were to halt the decline in salmon populations within five to ten years and establish increasing trends in abundance within 25 years. Details of the strategy reside in two documents:

- A final biological opinion by NOAA Fisheries required under the ESA that will guide operations of the 29 federally owned dams in the Columbia Basin for salmon and steelhead recovery.
- A final Basinwide Salmon Recovery Strategy (also referred to as the "All-H" Strategy) that incorporates requirements of the biological opinion with other measures to improve hatcheries, limit salmon harvest, and, most importantly, restore salmon habitat.

Also on December 21, 2000, the USFWS released its final biological opinion on the effects of power system operations on the endangered Kootenai River white sturgeon and threatened bull trout. This strategy was based on the best available science, extensive public input, and broad discussions and consultations with tribal, state, and local authorities. It placed the highest priority on actions with the best chance of providing solid, predictable benefits for the broadest range of species. It also established mechanisms to gauge success, factor in new science as it became available, and adjust the recovery actions at major midterm reviews as needed. Federal agencies are using this strategy as a blueprint to guide their recovery efforts and interactions with state and local governments and tribes.

Monitoring and Evaluation: How to Evaluate Restoration Projects?

A decade ago, the Scientific Review Group stated:

> *We again call for immediate development and implementation of a system-wide monitoring and evaluation program that is also responsive to critical uncertainties.*
>
> -- Critical Uncertainties in the Fish and Wildlife Program (SRG 93-2)

In essence, monitoring measures change while research identifies the causes of the change. The purpose of the monitoring and evaluation strategies of the fish and wildlife program is to assure that the effects of actions taken under the program are measured and analyzed to provide better knowledge of the results, and then use this knowledge to direct future actions. The absence of a monitoring and evaluation program for the Columbia River Basin has confounded restoration and planning efforts for decades.

Rather than try to design a complete and comprehensive monitoring program, which it probably cannot afford, the region should identify and develop consensus about how much and what types of monitoring are needed, and can be afforded, for managing an effective fish and wildlife restoration program. All opportunities to conduct collaborative research on monitoring should be fully exercised. For example, the effectiveness research being conducted in pilot watersheds under the fish and wildlife program is highly analogous to work in Puget Sound under the aegis of the Pacific Coastal Salmon Recovery Fund. Further, the Bonneville Environmental Foundation has recently inaugurated similar work. These three corollary efforts, being conducted under separate mandates, point out the need for coordination at a broad scale. The issues of scientific leadership, institutional innovation, and governance are being addressed by the Pacific Northwest Aquatic Monitoring Partnership in regards to the prioritization, design, and coordination issues for large-scale monitoring linked to management experiments.

Pacific Northwest Aquatic Monitoring Partnership

> *A regional science based monitoring and evaluation program is necessary to assess the status of populations and habitat, as well as the adequacy of management and restoration actions in achieving restoration goals. Research needs include monitoring technologies, indicators of stock success and environmental health, databases for information storage and retrieval, straightforward evaluation procedures, and mechanisms to ensure communication to those who implement adaptive management.* (Emphasis added.)
>
> -- Committee on the Environment and Natural Resources, 2000

Several years ago, Federal Executives asked staff of the U.S. Forest Service's Aquatic and Riparian Effectiveness Monitoring Program to develop a monitoring partnership with Washington, Oregon, and California agencies in support of the President's Forest Plan. This resulted in an ad hoc group of state and federal natural resource and watershed specialists meeting since November 2001 to coordinate and integrate their different watershed condition monitoring efforts. This group is now operating as the Pacific Northwest Aquatic Monitoring Partnership or PNAMP. In recognition of the common objectives and overlap among participants in existing monitoring programs, the initial group decided to expand their partnership group to include the federal research, monitoring and evaluation planning and coordination effort, and to bolster the effort by inviting participation from tribal organizations. Participants to date have included a wide range of organizations – state, federal, and tribal.

The PNAMP is developing a regional coordination plan for monitoring and evaluation, separate from this research plan. Nevertheless, many of the research needs essential for the development of the monitoring plan are identified in this research plan. The relationship between these two planning documents should be viewed as complementary. However, the scope of the PNAMP plan differs from that of the research plan in two ways. First, although the Partnership's plan includes research efforts, it is focused on a single subject area, monitoring and evaluation. In contrast, the Council's plan spans many topic areas, including monitoring and evaluation. Second, the Partnership's plan encompasses the region within which the President's Forest Plan is being implemented, from the Canadian border south to northern California, whereas the Council's plan only encompasses the Columbia River Basin.

Federal Research, Monitoring, and Evaluation Plan

In NOAA's 2000 biological opinion, monitoring and evaluation is a strong and central theme. Over a two year period, Bonneville, the Corps, and the Bureau of Reclamation work with NOAA Fisheries to develop a *Research, Monitoring, and Evaluation (RME) Program for the NOAA Fisheries 2000 Federal Columbia River Power System (FCPRS) Biological Opinion and a Columbia River Federal Salmon Recovery Strategy MOU.* Recommendations for research relevant to monitoring and evaluation and the hydrosystem identified in the RME plan are reported in this research plan. The ISRP reviewed the plan and issued Review of Draft Action Agency and NOAA Fisheries RME Plan (2004-1), which made several recommendations for revisions to the plan. Since then the Action Agencies have not responded to the ISRP or to Council staff as to the status of these recommendations. It is unclear whether the Action Agencies intend to go forward in reliance on their draft RME plan, or to instead use the RME section of the UPA to guidance RME activity in lieu of the original plan.

The federal RME plan focused on stocks of anadromous fish listed under the ESA and called for programmatic monitoring and expanded coordination with other federal and state monitoring programs. In contrast, the monitoring coordination plan of the Pacific Northwest Aquatic Monitoring Partnership embraces monitoring for watershed conditions, status and trends, and project effectiveness. Although the federal monitoring plan addresses a narrower range of resources, it was developed over a two-year period and will make a significant contribution to the regional monitoring efforts.

Pacific Coastal Salmon Recovery Fund

The Pacific Coastal Salmon Recovery Fund (PCSRF) was established in fiscal year 2000 to provide grants to the states and tribes to assist state, tribal and local salmon conservation and recovery efforts. The goal of the PCSRF is to make significant contributions to the conservation, restoration, and sustainability of Pacific salmon and their habitat. The PCSRF was requested by the governors of the states of Washington, Oregon, California and Alaska in response to ESA listings of West Coast salmon and steelhead populations. The PCSRF supplements existing state, tribal and federal programs to foster development of federal-state-tribal-local partnerships in salmon recovery and conservation. It also promotes efficiencies and effectiveness in recovery efforts through the enhanced sharing and pooling of capabilities, expertise and information.

The recovery of sustainable salmon populations will likely take decades, and require a substantial investment. Nonetheless, it is important to track the work accomplished by current investments and measure activities and changes on a regular basis. NOAA Fisheries has developed a comprehensive performance measurement system for the PCSRF in conjunction with the states and tribes in response to requests by Office of Management and Budget and Congress for program accountability. The MOUs between NOAA Fisheries and the states and tribes, which previously established criteria and goals for prioritizing PCSRF project funds have been amended to include these program-wide performance goals and reporting metrics. It is anticipated that the aggregation of these project level reporting metrics, combined with larger

scale watershed and subbasin assessments and results from monitoring and evaluation efforts, will allow, over the long term, an assessment of program effectiveness in terms of increased numbers of salmon. Bonneville is currently adopting these metrics into its project tracking system.

Bonneville Environmental Foundation

The Bonneville Environmental Foundation (BEF) initiated its Model Watershed Program in October 2003. BEF signed two 10-year agreements supporting long-term, monitoring-intensive watershed restoration efforts in Idaho's lower Kootenai River and the Chinook River in southwest Washington. In agreements with the Kootenai Tribe of Idaho and Sea Resources (a community-based watershed restoration organization located in Chinook, WA.), BEF has committed to provide scientific oversight, an independent peer review panel, and at least $500,000 in support of restoration and quantitative monitoring efforts over a 10-year period.

With its model watershed approach, BEF is hoping that long-term investments in scientifically accountable restoration programs will prove more effective than short-term and piecemeal project grants scattered among Pacific Northwest watersheds. Over time, BEF plans to seek additional resources and apply its own funds to support 10 to 12 long-term Model Watershed programs across the Pacific Northwest.

There is a clear opportunity to link the three sets of pilot intensively watersheds to increase the pool of experimental sites, which would save funds and time, specifically the BEF projects, the PSCRF projects, and the pilot watershed work under the FCRPS Biological Opinion.

Short-Term Research Recommendations

1. Design and implement a research monitoring (Tier 3) effort at selected locations in the Columbia Basin to establish the underlying causes for the changes in population and habitat status identified in Tiers 1 and 2 monitoring.

2. Determine juvenile hydro survival salmon and steelhead survival through the hydropower system (priority total system/secondary in-river), in relation to performance standards.

3. Determine the extent of harvest incidental mortality in terms of impact on pre-spawning survival and spawning success for listed species.

Estuary

The estuary is an important ecological feature that has been impacted by local habitat and upriver management actions. While less is known about the potential for improvement in the estuary than other parts of the Columbia River Basin, there are indications that substantial improvements are possible, and that these improvements may benefit most of the anadromous fish populations in the Columbia River Basin. Although all of the investment and effort in the Fish and Wildlife Program flow through this unique environment, the interaction of changes in the estuary with restoration projects has not been evaluated. A precautionary approach should be taken, given the current state of most salmonid populations in the Basin, the magnitude of change in the estuary, and the lack of prior research.

Short-Term Research Recommendations

1. Collect additional shallow-water bathymetry data for refining the hydrodynamic modeling and identifying/evaluating potential opportunities for specific restoration projects.

2. Increase understanding of juvenile and adult fish migration patterns. The Army Corps of Engineers is funding juvenile fish research in the estuary, as research regarding adult fish was not recommended in the regional forum (the forum is the means of collaborating the ESA-related recovery work of federal agencies in the Columbia River Basin).

3. Improve understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control the invasive species.

4. Improve understanding of the biological meaning and significance of the estuarine turbidity maximum relative to fish restoration actions.

Long-Term Research Recommendations

1. Establish an allocation of water within the annual water budget for the basin that would simulate peak seasonal discharge, increase the variability of flows during periods of salmonid migration, and restore tidal channel complexity in the estuary, aided by removing pile dikes where feasible.

2. Increase genetic research to identify genotypic variations in habitat use.

3. Increase understanding of sediment transport and deposition processes in the estuary.

Natural Variation and Ocean Productivity

Shifts in oceanic regime involve substantial changes in the distribution of species, the structure of marine food chains, and the physical processes of biological production. Anticipating such change and understanding its effects on salmon production in the Columbia Basin will require evaluation of ecological indicators other than the abundance of salmon. Decadal cycles of ocean productivity have the potential to mask changes in the survival of salmon during freshwater phases of their life cycle, leading to erroneous interpretation of the performance of restoration efforts and increased losses of some stocks (CENR, 2000). Therefore, remediation for poor ocean conditions should entail taking an ecosystem approach to salmon management in which variability and diversity on the freshwater side are considered normal attributes to be safeguarded.

Long-Term Research Recommendations

1. Determine the relative effects of the ocean on different fish stocks compared to the effects of

inland actions.

2. Research on effects of ocean conditions on productivity of salmon must be integrated with estuarine and riverine research.

Toxics

Environmental Protection Agency

The Environmental Protection Agency's (EPA) "Watershed Protection Approach" is a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within hydrologically-defined geographic areas, taking into consideration both ground and surface water flow. Watersheds are the geographic unit below a subbasin, and are at the scale at which much of the restoration and planning work that will follow subbasin plans will occur. EPA provides many financial and technical resources to support local watershed protection efforts undertaken by state and tribal governments, public interest groups, industry, academic institutions, private landowners and concerned citizens. EPA has partnerships with the States and Tribes of Alaska, Idaho, Oregon, and Washington.

EPA's Watershed Protection Approach is a strategy for effectively protecting and restoring aquatic ecosystems and protecting human health. This strategy has as its premise that many water quality and ecosystem problems are best solved at the watershed level rather than at the individual water body or discharger level. Major features of the Watershed Protection Approach are: targeting priority problems, promoting a high level of stakeholder involvement, integrated solutions that make use of the expertise and authority of multiple agencies, and measuring success through monitoring and other data gathering.

EPA also implements water quality standards that are the foundation of the water quality-based control program mandated by the Clean Water Act. Water Quality Standards define the goals for a water-body by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. A Total Maximum Daily Load or TMDL, is a tool for implementing water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the allowable loadings or other quantifiable parameters for a water-body and thereby provides the basis to establish water quality-based controls. These controls should provide the pollution reduction necessary for a water-body to meet water quality standards.

The EPA Office of Water has various programs that store data in associated databases. These databases are separately managed with little coordination among them. Under Watershed Assessment, Tracking & Environmental Results (WATERS), an integrated information system for the nation's surface waters, these program databases are being connected to a larger framework. This framework is a digital network of surface water features known as the National Hydrography Dataset which can link one program database to another, so that information can be shared across programs.

Although the Office of Pesticide Programs has included endangered species considerations in its risk assessments for many years, the Endangered Species Protection Program (ESPP), was started in 1988. It is largely voluntary at the present time and relies on cooperation between the U.S. Fish and Wildlife Service, EPA regions, states, and pesticide users.

Western Fisheries Research Center

The Western Fisheries Research Center (WFRC) is part of the U.S. Geological Survey. WFRC conducts research on how ecosystem dynamics affect critical living aquatic resources in large river systems. WFRC is supporting the research needs of the U.S. Bureau of Reclamation, Army Corps of Engineers, and the Bonneville Power Administration. In terms of large ecosystems with multiple collaborators, the WFRC is working in the Columbia, Klamath, and Sacramento-Bay/Delta systems. Multiple collaborators and partners are also involved in WFRC contaminants projects, such as USFWS, U.S. Bureau of Reclamation, NOAA Fisheries, and the Water Resources Division of U.S. Geological Survey. Management of salmon by these entities and by NOAA Fisheries will also require increased research in estuaries.

Short-Term Research Recommendations

1. Identify and quantify sources of toxic contaminants, which are contributing to the exposure of salmon leaving the Lower Columbia River.

2. Determination of the biological consequences of contaminant exposure in salmon, as well as consequences for other species, notably prey species and higher trophic levels, such as piscivorous birds.

Long-Term Research Recommendations

1. Contaminant monitoring and research should be conducted as part of overall investigations of chemical habitat quality, including studies of organic carbon transport and cycling.

2. Characterization of exposure patterns in wild versus hatchery fish, in populations with different life histories and patterns of estuary use, in various listed ESUs.

Invasive Species

Mechanisms must be identified to reduce or eliminate the reproductive capacity or dispersal of non-native species in native salmonid habitats if riverine controls, for example by the restoration of flushing flows, prove ineffective in controlling non-native species.

Short-Term Research Recommendations

1. Determine the ecological consequences of invasions, specifically, competition, predation, and

cascading trophic effects on native species, nutrient cycling, effect of management activities.

2. Determine how to detect low-density populations of invasive species, develop new monitoring techniques and optimized search protocols.

3. Determine the feasibility of developing rapid response methodologies to eliminate newly introduced species at the source of introduction before they spread.

4. Determine the potential nontarget impacts of management techniques, specifically the sub-lethal impacts of herbicides on salmonids.

Long-Term Research Recommendations

1. Determine whether there are environmental constraint on the abundance and distribution of currently established or eminently threatening species.

2. Determine what factors limit invasive species in their native range, such as viruses, bacteria, fungi, parasites, predators.

3. Determine the ecological impacts of "naturalized" non-indigenous species.

4. Determine whether regionally accepted non-indigenous species, such as warm-water fish, can be
managed to minimize ecological effects.

5. Evaluate alternative pesticides for use in eradicating specific aquatic nuisance species.

Subbasin Planning: Where and When to Implement Research Projects?

> *... to ensure that relevant scientific information, including socioeconomic information is available to decision makers in a useful format, a structured process is needed to involve community stakeholders and tribal governments and their issues, values, and priorities.*
>
> -- Committee on the Environment and Natural Resources, 2000

No one should expect science alone to resolve the challenges facing the region. Science has made, and will continue to make, a significant contribution to the regional dialogue on restoration and recovery. Yet science remains but one of the streams of interdisciplinary information flowing to decision-makers who allocate common property resources. Social considerations and economic factors are also an important part of the mix of information before decision-makers, and at times these factors will be determinative.

Sound science, thoughtful planning, and hard work on the ground are all important ingredients to the success of any restoration program. Yet without strong local support for restoration activities, the future of many Columbia River Basin species will remain in question. In 2000 the Council initiated subbasin planning in order to help local entities develop their own restoration

plans. Subbasin planning has helped people define the future they seek for natural resource amenities in their subbasins, and thereby define their legacy to future generations. Subbasin planning have helped identify coordination needs and opportunities for fish and wildlife restoration by integrating strategies in the Council's fish and wildlife program with other federal, state, tribal, Canadian, and volunteer fish and wildlife restoration programs. Subbasin plans have defined the goals, biological objectives, and strategies for individual subbasins. Through subbasin planning, inventories of regulatory requirements have been developed including ESA and Clean Water Act measures, water and land management objectives affecting fish and wildlife have been clarified, and program funding will be coordinated to maximize benefits to fish and wildlife. The cooperative and inclusive participation of federal, state, tribal, and local stakeholders in subbasin planning created the opportunity for subbasin plans to contain a collective expression of the critical uncertainties and research priorities within a subbasin.

Both top-down, and bottom-up approaches are necessary to fully implement the research plan. Subbasin plans embody the bottom-up approach, as they will contain input from a wide range of stakeholders. The research plan provides regional-level guidance and a top-down approach to the identification of basinwide research needs that can be addressed in the next project selection process or by requests for proposals. Thus, implementation of research projects identified through subbasin planning (bottom-up) should be consistent with the overall research plan (top-down).

The research plan will support research recommendations that have broad application to other provinces, or to the entire Columbia basin. Subbasin plans identify research needs either within a subbasin (geographically specific), or a prevalent need within the province or subbasin. Through provincial review and project selection, research projects that can have application beyond the subbasin will be reviewed more favorably than those with a smaller geographic scope. Research projects identified through subbasin plans can also be proposed for funding through any relevant RFPs.

It will be important to understand the collective research needs within a province after subbasin plans are adopted. As part of the Council's commitment to establishing provincial goals and objectives, assessing provincial research needs should be a part of that exercise. The Council will collating the research needs from each subbasin plan within a province, asses the major research needs, and compare them to the needs in other provinces for a basinwide perspective. As these uncertainties and research recommendations are identified, they will be incorporated in future iterations of this research plan. Naturally, there will be other research needs not identified through the subbasin planning process. The overall assessment of provincial or basinwide research needs therefore will not be limited to just those identified through subbasin planning.

State Research Initiatives

Research recommendations from Oregon and Montana are already incorporated throughout text.

Recovery Planning for Endangered Species: How Much Research Is Enough?

NOAA Technical Recovery Team Products

The ESA requires that recovery plans contain objective, measurable goals for delisting; a comprehensive list of the actions necessary to achieve the delisting goals; and an estimate of the cost and time required to carry out those actions. In addition, NOAA Recovery Planning Guidelines suggest that recovery plans include an assessment of the factors that led to population declines or that are impeding recovery. Finally, it is important that the plans include a comprehensive monitoring and evaluation program for gauging the effectiveness of recovery measures and overall progress toward recovery.

To implement these elements of recovery, NOAA Fisheries has formed geographically based Technical Recovery Teams (TRTs), in coordination with existing science teams and ongoing conservation planning efforts. NOAA Fisheries is also working with state, local, regional, tribal, and private entities to develop a collaborative recovery planning process for each planning area. The TRTs will provide technical support and analysis to these efforts and have been convened for the Puget Sound and Willamette/Lower Columbia/Southwest Washington regions, and the Interior Columbia River Basin. The TRTs will develop products that:

1. Identify population and ESU de-listing goals;
2. Characterize habitat/fish abundance relationships;
3. Identify the factors for decline and limiting factors for each ESU; identify the early actions that are important for recovery;
4. Identify research, evaluation, and monitoring needs; and,
5. Serve as science advisors to groups charged with developing measures to achieve recovery.

The planning component of the ESA recovery planning process will focus on identifying the measures and actions necessary to achieve the recovery goals identified by the TRTs. According to NOAA Fisheries, recovery goals must, at a minimum, restore listed ESUs to levels at which they are no longer threatened and can therefore be de-listed under the ESA. NOAA Fisheries believes it is critically important to ground the recovery planning process in the many state, regional, tribal, local, and private conservation efforts already underway throughout the region, such as subbasin planning.

Long Term Commitment to Restoration and Recovery

Spirit of the Salmon (Wy-Kan-Ush-Mi Wa-Kish-Wit) is the title of the Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes. It provides a framework to restore the Columbia River salmon. A key theme of Spirit of the Salmon is that it makes a multiple generational commitment to salmon recovery. The first volume of the two-volume plan sets out 13 scientific hypotheses and the recommended actions associated with each, along with 10 institutional recommendations. Many of these recommendations comport with those of other large scale planning documents. The interests of the tribes touch all of the research topics in this plan, so they will be key partners in its implementation.

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IV. Appendixes

Appendix A. Mandate for a Columbia River Basin Research Plan

Northwest Power and Conservation Council

In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act[1] that authorized the states of Idaho, Montana, Oregon and Washington to create the Northwest Power and Conservation Council. The Act directs the Council to develop a program to:

> *"protect, mitigate and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries ... affected by the development, operation and management of [hydroelectric projects] while assuring the Pacific Northwest an adequate, efficient, economical and reliable power supply."*

Directives for a Columbia River Basin Research Plan

Basinwide Provisions of the Fish and Wildlife Program

The Council's Columbia River Basin Fish and Wildlife Program is one of the largest regional efforts in the nation to recover, rebuild, and mitigate impacts of hydropower dams on fish and wildlife. As a planning, policy-making, and reviewing body, the Council develops and then monitors implementation of the program, which is funded by the Bonneville Power Administration (Bonneville) and implemented by tribal, state, and federal fish and wildlife managers and others. In its vision for the program, the Council states four overarching biological objectives:

1. A Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife.

2. Mitigation across the basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem.

3. Sufficient populations of fish and wildlife for abundant opportunities for tribal trust and treaty right harvest and for non-tribal harvest.

4. Recovery of the fish and wildlife affected by the development and operation of the hydrosystem that are listed under the Endangered Species Act.

The Council adopted the first fish and wildlife program in November 1982. In that plan and in subsequent updates, the Council called for development of a research plan but also adopted specific measures for research without clear prioritization of remaining critical uncertainties. The 2000 Program, the latest revision of the program, marks a significant departure from past versions, which consisted primarily of a collection of measures directing specific activities. The

[1] Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Public Law 96-501, 94 Stat. 2697 (December 5, 1980), codified with amendments at U.S Code Annotated 16, section 839 (2000)). See Section 839b(h)(6)(B).

2000 Program establishes a basinwide vision for fish and wildlife along with biological objectives, as noted above, and action strategies that are consistent with the vision. The purpose of the research strategy in program is to identify and resolve key scientific uncertainties. The program calls for the development of a basinwide research plan to address those uncertainties.

The heart of the program is a set of immediate actions to improve conditions for fish and wildlife in the Columbia River Basin. Despite a large body of knowledge about the needs of fish and wildlife, there are still instances in which the region lacks the information to fully understand which actions will be most effective. The intention of the Council, and the Northwest Power Act, is for the region to make the best possible choice of actions based on the available information. Thus, lack of perfect information is not grounds for inaction.

Although "Research, Monitoring, and Evaluation" appears as specific strategy in the program, that strategy also provides a broader vehicle for reducing uncertainties that undercut the effective implementation of the full suite of strategies in the program. Ultimately, the program will be implemented through 52 subbasin plans that have been developed locally in the Columbia River Basin. Some of the subbasin plans have identified research needs that can be efficiently addressed from a regional plan.

Recommendations of the Four Governors

Another directive to develop a regional research plan was included in the *Recommendations of the Governors of Idaho, Montana, Oregon and Washington for Protecting and Restoring Columbia River Fish and Wildlife and Preserving the Benefits of the Columbia River Power System* issued in June of 2003. In regard to research, the Four Governor's Recommendation on Monitoring and Accountability stated:

> ...the Council, working closely with the States, federal Agencies and Tribes should develop ... by year's end, a draft systemwide research plan with budgets and priorities.

The directive of the Four Governors was met by the submittal of a draft Columbia River Basin research plan to the Council on December 31, 2003.

The Objectives, Audience, and Scope of the Columbia River Basin Research Plan

In order to further the objectives of the fish and wildlife program, this research plan will direct research activity in support of anadromous and resident fish and wildlife in the Columbia River Basin. The research plan will be an important tool for managing the fish and wildlife program because it can inform Council decision-making, facilitate scientific review, focus project selection, and provide a basis for redirecting future research. The plan will reduce management uncertainty by increasing scientifically based knowledge. In brief, the objectives of the plan include identification of critical uncertainties, formulation of research recommendations, and identification of priorities for funding. Additional plan objectives include:

1. Increased accountability for the annual expenditures of research funds.

2. Improved input from independent scientific review, fish and wildlife agencies and tribes, independent scientists and other interested parties in the region.

3. Improved monitoring, evaluation, and the application of results.

4. Improved coordination among mainstem research programs.

5. Improved coordination with the research elements of subbasin plans.

6. Improved accessibility of information from the fish and wildlife program.

The primary audience for the plan is policy and decision makers responsible for natural resource management within the Columbia River Basin, such as the Council members and other regional executives. The plan also will provide useful guidance to planners, researchers, and project sponsors. The scope of issues in this draft plan does not include recounting the factors and events contributing to the decline of fish and wildlife species within the Columbia River Basin, as that history has been described by numerous other sources. The geographic scope of the plan is limited to the Columbia River Basin. In this draft form, the research plan addresses the fish and wildlife program and key pieces of research activity involving the Army Corps of Engineers, the U.S. Bureau of Reclamation, Bonneville, NOAA Fisheries, U.S. Fish and Wildlife Service and other entities. The next phase of development of the draft plan will include broadening the scope from an initial focus on the fish and wildlife program and implementation of the biological opinions to integration with other research programs, such as those of the U.S. Geologic Survey and the U.S. Environmental Protection Agency, and the Tribes.

Proposed Schedule for Completing Research Plan

Oct 1	Commence 30-day public review period
Oct 30	Complete 30-day public review period
Nov 22	Commence 30-day ISAB/ISRP review period
Dec 7-9	ISAB/ISRP discuss research plan at Seattle meeting
Dec 22	Complete 30-day ISAB/ISRP review period
Jan 31	Complete revisions to plan based on ISAB/ISRP review
Feb 15-17	Present final research plan to Council (contingent on potential schedule conflicts with adoption of subbasin plans and the power plan)
March 15	Final Columbia Basin Research Plan completed

Appendix B. The Development of a Columbia River Basin Research Plan

Past as Prologue

Best Scientific Information

The Northwest Power Act instructs the Council to prepare a fish and wildlife recovery program for the Columbia River Basin that includes measures "...based on, and supported by, the best available scientific knowledge." The Council has sought "the best available scientific knowledge" in different ways as the fish and wildlife program evolved. The Power Act directs the Council to review the program at least every five years, and the Council has done so. With each revision, the Council paid attention to the mandate regarding best available scientific knowledge. In preparing the first version of the program, the Council formed the Scientific and Statistical Advisory Committee to assist in evaluating recommendations for measures to include in the program. In the 1984 Program, the Council created a Fish and Wildlife Committee comprising four Council members and gave the committee duties that included assessing past and present research projects. In the 1987 program revision, the Council created Technical Working Groups consisting of the representatives of agencies, tribes and some other parties. The Technical Working Groups were charged with summarizing existing information and identifying fish and wildlife program research needs in areas such as hatcheries, fish disease and habitat. The Independent Science Group (ISG) was created by the Council in the 1992 Program to provide advice and to conduct a review of the program, and that review became *Return to the River* (1996). The Scientific Review Group (SRG) and the ISG later evolved into the ISAB and the ISRP.

The Council later addressed the need to satisfy the "best available scientific information" provisions of the Act through by utilizing the recommendations of the Basin's fish and wildlife managers and incorporating independent scientific review into the decisionmaking process. In most years, the fish and wildlife managers, through the Columbia Basin Fish and Wildlife Authority (CBFWA), develop a draft annual program implementation work plan for the projects proposed for funding. This draft annual work plan is the culmination of a technical and management review of the feasibility of all proposed projects, and it establishes a proposed annual budget and project priorities. The ISRP and the Council review the projects proposed for funding in the context of the fish and wildlife managers' draft work plan. The project reviews and advice of the fish and wildlife managers are valuable to the Council as it deliberates on its funding recommendations. In sum, the Council has an established process to satisfy program measures on the best available scientific knowledge.

The Council recognizes that the quality of the information collected through research is important to the credibility of its decision-making. Every year the Council implements its mandate to base program measures on the best available science by recommending the funding of numerous research projects to gather necessary scientific knowledge.

Prior Efforts to Identify Research Priorities

Since its inception, the Council has made significant efforts to identify research priorities including the following. Section 206 of the Council's 1987 Fish and Wildlife Program contained what could be called a research plan for salmon and steelhead. Section 206 called on Bonneville to fund research in specified areas of emphasis over the ensuing five years. It also directed Bonneville to fund the Technical Working Groups whose responsibilities included developing five-year workplans in those areas of emphasis. The workplans were to be approved by the Council, thus becoming Council plans. Thus, section 206 provided the basis for the appointment of Technical Working Groups and their development of five-year research plans that included assessments of past research and identification of research needs.

In *Return to the River*, the Independent Scientific Group (1996) developed a conceptual foundation for restoration of salmonid fishes in the Columbia River Basin. In 1998 the Council published the *Development of a Regional Framework* (Document 98-16) that introduced a set of broad scientific principles (Part I) and applied these principles to a description of the Columbia River as an ecosystem (Part II). This document also states that "A third part of the scientific foundation, a set of analytical tools based on Parts I and II, remain to be developed."

The Council continued to develop an explicit scientific foundation by articulating a set of eight scientific principles and discussing their implications for salmon restoration (*see* page 15, 2000 Fish and Wildlife Program, Council Document 2000-19). These principles were derived from a number of other reviews and recovery strategies for Columbia River salmon including *Return to the River*. Other science review groups (President's Committee on the Environment and Natural Resources, 2000; and the National Research Council, 1996) have also emphasized the need for an ecosystem perspective as a basis for designing a recovery program for salmon in the Pacific Northwest. The science foundation developed by the Council represents an important step in the development of a recovery program founded on ecological principles.

Thus, over the last decade these efforts have helped improve the ability to define uncertainties and develop research recommendations to address them. This should be viewed as an evolutionary progression, as it is now possible to separate some of the broader, vexing uncertainties into more discrete research questions or recommendations. While a derivative of these prior efforts, this draft research plan is also a continuance of them. It attempts to provide greater specificity in the application of scientific principles to critical uncertainties, rather than simply recommending a set of tools for addressing them.

2002 Draft Columbia River Basin Research Plan

In January 2002, Council staff requested the ISRP to review an initial effort to complete a draft regional research plan. On April 15, 2002 the ISRP released its review (Council Document ISRP 2002-4), which recommended a substantial reorganization of the staff's draft plan. The ISRP found that the draft essentially defined existing research as the research program. The ISRP commented that the work underway at the project scale, or as elements within projects, did not constitute a program nor provide a sense of future direction. The draft plan also promoted a bottom-up approach to the identification of research priorities, tied to subbasin planning, that

would result in repetition of research efforts. Rather than addressing policymakers, it tried to address multiple audiences, providing detailed guidance for those contemplating submission of a research proposal, as opposed to those managing a program. It also provided a profile of on-going research at that time and helpful information regarding the funding process

Consequently in 2003, despite a history of coordination and prioritization efforts, the Council still did not have a research plan that identified critical uncertainties and prioritized research recommendations. This is not to diminish the excellent research that has been completed in the past at the project scale. However, new research should not be undertaken without benefit of a programmatic framework. In order to succeed, the research program must institutionalize accountability. For that reason it will be developed in tandem with a regional monitoring coordination plan.

Appendix C. Implementing the Columbia River Basin Research Plan

This plan identifies what types of research to fund. It also provides a rationale as to why to fund specific work and general recommendations as when to provide funding. Finally, it proposes a mechanism for how to fund much of the work necessary to the fish and wildlife program. However, this plan is not based on the assumption that the fish and wildlife program will fund all of the research needs of the region.

This section explains how the short and long-term elements of the research agenda described in Chapter III will be implemented. Much of the short-term and some of the long-term research recommendations will be implemented under the fish and wildlife program. New large-scale field experiments should be conducted collaboratively via shared funding arrangements with other entities. Therefore, this implementation section applies to both the short and the long-term elements of the research agenda, with the exception of multiple-sponsor projects.

Some research questions will require large-scale field experiments, and these will require collaborative treatment and shared funding sources. It might be argued that there are already de-facto large-scale field experiments underway, but they were not designed to resolve specific uncertainties or establish cause and affect relationships. It may be possible to link project-scale efforts together in order to achieve large-scale field experiments, such as by sharing controls for hatchery and habitat projects. However, the current funding structure does not facilitate development of controls. As a result, much of the research on hatchery effectiveness has been done without paired study of natural production. Similarly, much of the research on habitat treatments has been conducted without paired control sites. For these reasons, current research activity that resembles large-scale field experiments does so by default, not by design.

In 2000, the Council shifted from an annual funding cycle for projects to a three-year cycle. Because state and federal agencies remain on an annual funding cycle, it is difficult to make long-term funding agreements. Consequently, formal arrangements such as memoranda of agreements may be necessary to guarantee long-term funding commitments for selected large-scale field experiments. The Council must design the project selection process that will follow the adoption of subbasin plans in 2004.

Project Selection Under the Fish and Wildlife Program

The Northwest Power Act affords the Council broad discretion to define the procedures for conducting project review and selection for many projects funded by Bonneville. In general, the Act requires all projects to undergo an independent scientific review by the ISRP to ascertain their scientific and technical merits. The ISRP consists of eleven members assisted by a number of Peer Review Group members. The ISRP was created by amendment to the Northwest Power Act in 1996 and charged with providing scientific review of projects funded by Bonneville under the Council's program. Congressional report language subsequently expanded the role of the Panel to include scientific review of projects sponsored by the Corps and other federal agencies that are funded by Bonneville through reimbursement. The ISRP and the Council's review process have served to appreciably increase the level of scientific rigor in Bonneville projects and hopefully have increased the effectiveness of projects to meet the Program's vision. Unlike

the ISRP, that is solely under the Council's purview, the Independent Scientific Advisory Board (ISAB) is jointly sponsored by the Council, NOAA Fisheries, and the Columbia River Basin Indian Tribes. The ISAB provides general scientific advice on recovery efforts whereas the ISRP provides scientific review of specific project proposals.

In addition, proposals are evaluated within a policy context to determine their potential contribution to management decision-making. Regional fish and wildlife managers often provide recommendations to the Council on these matters. In general, the Council's recommendations for Bonneville funding rest on a mix of priorities, legal considerations, technical adequacy, management urgency, regional opportunities, and available funding.

This section briefly describes the operational context of the fish and wildlife program, including a brief description of the project selection and funding process. The draft research plan does not provide detailed guidance for project performance and administration. Bonneville has the primary responsibility for the implementation and management of research contracts pertaining to activities under the fish and wildlife program, executed by Bonneville's Contracting Officer Technical Representatives.

Beyond Technical Merit: New Review Criteria for the ISRP?

The ISRP and Scientific Peer Review Groups review projects proposed for funding to implement the Council's program through Bonneville's annual fish and wildlife budget. The 1996 amendment to the Northwest Power Act requires the ISRP to determine whether projects proposed for funding:

- Are based on sound science principles.
- Benefit fish and wildlife.
- Have clearly defined objectives and outcomes.
- Have provisions for monitoring and evaluation of results.
- Are consistent with the program.

Thus, current decision criteria for ranking projects as "fundable or not fundable" are based primarily on technical merit and do not include any specific reference to research priorities. Therefore, this draft plan proposes four new approaches to the implementation of research:

- First, ongoing projects containing objectives that approach, but do not squarely address a research recommendation set forth in Chapter I should be re-examined.
- Second, all knowledge gaps should be initially considered as research needs for which projects will be sought based on a sequential priority, rather than implemented concurrently.
- Third, new decision criteria for reviewing projects should be introduced for consideration by the ISRP. These criteria would provide additional guidance to

implement the research priorities identified in this plan. Additional criteria the ISRP might consider in its review include:

1. Does the proposed project address a discrete research priority or a discrete sub-issue of a complex research priority, which is defined in a request for proposals (RFP)?

2. Will resolution of the research question facilitate later treatment of related research questions?

3. Does the proposed mode of implementation require collaboration with other parties under a shared mandate?

- Fourth, RFPs should be used increasingly, in consultation with fish and wildlife managers, the ISAB and the ISRP to address specific research questions identified in this draft plan. Explicit review criteria for the particular research topic could be included in the RFP.

The project review process currently benefits from CBFWA's application of management criteria and from the ISRP's requirement that projects "benefit fish and wildlife." These criteria have been used to communicate the priority of projects. For example, a study may be technically sound but redundant with an ongoing project and thus not recommended for funding. With some exceptions, the Council and Bonneville generally have not provided enough specific direction in solicitations regarding the research questions that need to be addressed. RFPs should include specific criteria that project proponents should address in proposals and that the ISRP, the Council, and CBFWA should consider in their reviews.

By increasing specificity in research project solicitations, the fish and wildlife program can shift from a reactive mode to a proactive mode. The Council currently is on the receiving end of proposals submitted in response to solicitations that are geographic in scope. The Council does not actively seek proposals to address specific research questions. Because this draft research plan identifies ongoing research, research recommendations, and gaps, the opportunity exists to use RFPs, with designated budgets agreed to by Bonneville, to close the gaps. This approach would enable the ISRP review to remain primarily focused on the technical merit of proposed projects (the research, monitoring, and evaluation RFP effort for hatchery uncertainties is an example). The open solicitation approach has proved costly in terms of failing to address the knowledge gaps, frustrating project sponsors, and expending ISRP review time on proposals that neither the Council nor Bonneville would consider funding.

Project Selection Processes

This section describes how projects have been reviewed and selected in the past, and might be in the future. Please note that this prior experience will inform, but not dictate, the future project selection process, which is being developed for FY 06.

Rolling Provincial Reviews - For planning purposes within the Columbia River Basin, the Council has delineated 11 ecological provinces comprising groups of adjoining subbasins that have similar ecological attributes. These provinces constitute the geographic scale at which the recent project selection and funding process was implemented on a three-year cycle. Provincial project solicitations were initiated at different times throughout the year and involved large-scale mailings of general announcements and calls for proposals to broad distribution lists that included federal, state, tribal, and local agencies, universities, private industry, and the general public. The announcements of proposal solicitations were also posted on the Council's web site (*www.nwcouncil.org*), Bonneville's web site (*www.efw.bpa.gov*), and CBFWA's site (*www.cbfwf.org*).

Following the completion of the first round of provincial reviews in 2003, the ISRP began to draft a *Retrospective Review*. The report focuses on programmatic issues and observations identified in ISRP reviews dating back to the panel's first report in July 1997, and encompasses further review efforts related to the "measurable benefits" element of the retrospective task. The ISRP will complete this report in January 2005.

Each province has its own uncertainties concerning environmental issues and fish and wildlife populations, some of which might be resolved by research projects. Subbasin plans should help identify the most appropriate geographic locations for siting research projects. In cases where multiple provinces share similar uncertainties, solutions in one province may inform efforts in others. Project sponsors would remain free to propose research projects unique to their geographic location but could be encouraged to propose research that provides a basis for extrapolation outside of the province in which the project is located.

At this time, the future project selection process is under development. The sequence of when to solicit RFPs, in conjunction with solicitations to meet other needs identified in subbasin plans, will need to be resolved. An effort should be made to allow those research projects with basinwide implications to compete with each other in the same solicitation, instead of being proposed in multiple provincial reviews.

Recommendation: Where feasible, research projects in one province should have broad application to other provinces, or to the basin as a whole.

Innovative Project Reviews - The Innovative Project category was suggested by the ISRP in past annual program reviews and was designed to improve knowledge, encourage creative thinking, and provide an opportunity for project sponsors to test new methods and technologies. Innovative projects were funded in Fiscal Years 1998, 2000, 2001, and 2002, and the Council adjusted the selection process each year the process was used. Although Council staff supports the Innovative Project concept, staff did not recommend conducting an Innovative Project selection process for 2004, because funding the pending provincial review recommendations for 2004 exhausted the available funds. Nevertheless, Council staff recognizes the value in funding innovative projects and believes that the fish and wildlife program's research plan will provide greater focus to future funding of innovative projects. Given the intractability of some research challenges it is important to keep the spark of innovation alive. Innovation is a critical element

of any large management program or research program and should be encouraged. Council members have expressed continued support for an innovative process.

Requests for Proposals - In the past, the Council identified questions of particular importance and initiated requests for proposals in coordination with Bonneville as needed.

Recommendation: Request for Proposals should be used independent of, or in concert with, broader solicitations to ensure the efficient effort of project sponsors, the ISRP, the managers, and the Council.

The future form of the project selection process has yet to be determined. Future project solicitations that occur after completion of the research plan may attract research proposals consistent with recommendations in the plan. However, for research recommendations for which no proposals are forthcoming, and/or for recommendations the Council decides to implement in the interim, requests for proposals could be initiated.

Project Selection Under the Corps' Fish Program

In contrast to the Council's program, the Corps funds research as prioritized by the regional forum and comprehensive plans such as the NOAA Biological Opinion and the Implementation plans of the hydro system Action Agencies. The Corps solicits pre proposals based on regionally ranked research needs. Research is approved following the iterative development of pre-proposals into final documents, whereby they are funded based on their quality and the regional ranking of the research need. At times, the Corps scheduling requirements necessitates some proposals to be malleable to reflect newly acquired data and to adjust to changing runoff forecasts. A great deal of responsibility is thereby placed on researchers to deliver the final proposal through the iterative proposal review process.

The Corps believes that it is important for their fish program to coordinate with the Council's program. However, while similar, the programs exist on parallel paths due to their different overall purposes. The Corps program focuses primarily on project specific fish passage issues, usually at hydropower facilities, as opposed to the Council's program taking a broader system-wide approach.

Meeting Fish and Wildlife Program Standards

Evaluation and Reporting of Research Results

It is important that all projects reach completion in a timely manner. At the present time, many researchers do not end their projects at the completion of the performance period but add new objectives that extend the performance period. This gives rise to projects with multiple and sometimes unrelated objectives that more closely resemble small programs than discrete projects. ("Infrastructure" projects may warrant an exception to the requirement for an end date.)

Recommendation: Specific ending dates should be required for project objectives and tasks to help sponsors meet their intended deadlines.

In order to satisfy their contractual obligation, sponsors should be required to submit to Bonneville a final report at the conclusion of every research project. The final report should be in a form that facilitates review of the results. Research data should be made available to scientific collaborators, administrators, and the public for additional analyses. The public nature of Bonneville funding implies that research results are the property of the general public. Bonneville should post all final research reports on its website to facilitate access. The final reports, and any other products derived from them, should be submitted to the StreamNet Library. This library includes materials relating to the resources of the Pacific Northwest and maintains a regional depository of all research products funded under the fish and wildlife program. The StreamNet Library provides regional services that include reference, referral, database searching, inter-library lending, and document delivery.

Data Management

There are many different interests and initiatives concerned with improving data collection or management in the Columbia Basin and the Pacific Northwest. These efforts involve many different constituencies, mandates, and obligations. At present, there is no common regional data management network that links these interests and initiatives. To address this situation, the Council has initiated a process for identifying data needs in the basin, surveying available data, and filling any data gaps. The Council, NOAA Fisheries, and other regional entities supporting this effort consider it imperative to develop a regional data network. This network would utilize existing databases, facilitate data management and sharing, help subbasin planners, and underpin salmonid recovery efforts under the FCRPS Biological Opinion.

A memorandum of agreement between the Council and NOAA Fisheries guides this initiative, which is currently developing an administrative arrangement, a cost sharing agreement, and a draft memorandum of understanding for potential partners in regional information system development. This initiative has been supported within the region by the ISRP[2], from independent analysis by Science Applications International Corporation (SAIC)[3], and in comments received from the public. The data management strategy is also intended to increase the public accountability of this program by making the results accessible not only to specialists, but also to the public at large. The Council is collaborating on a process for establishing an Internet-based system for the efficient dissemination of data for the Columbia Basin. This system will be based on a network of data sites, such as Streamnet, Northwest Habitat Institute, Fish Passage Center, Columbia River Data Access in Real Time (DART), and others, linked by Internet technology.

The methods and protocols used in data collection must be consistent with guidelines approved by the Council and adopted by the region. It is important to note that while the ISRP checks these criteria, it is Bonneville who must enforce the guidelines. Guidelines appropriate for the collection and reporting of data at the project scale include:

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[2] Independent Scientific Review Panel. *Report of Databases Funded through the Columbia River Basin Fish and Wildlife Program.* ISRP 2000-3. May 11, 2000.

[3] Science Applications International Corporation. *Recommendations for a Comprehensive and Cooperative Columbia River Information Management System.* Report to the NWPCC, April 30, 2003

- The project must have measurable, quantitative biological objectives.
- The project must either collect or identify data that are appropriate for measuring the biological outcomes identified in the objectives.
- Projects that collect their own data for evaluation must make this data and accompanying metadata available to the region in electronic form. Data and reports developed with Bonneville funds should be considered to be in the public domain. Data and metadata must be submitted within six months of their collection.

Appendix D. Sources of Critical Uncertainties and Research Recommendations for the Columbia River Basin

The critical uncertainties identified in this document were generated from evaluation of independent science group reports, recommendations from national science groups, the fish and wildlife program, the biological opinions, and other regional research plans

Research Recommendations from the Council's Independent Science Groups

The Council has relied on committees of scientists for their expert advice on fish and wildlife issues ever since the Council was formed. In the early 1990s, the Council asked its Scientific Review Group (SRG) to identify critical scientific uncertainties for the purpose of focusing implementation of the fish and wildlife program. In January 1993, the SRG issued its report, entitled *Critical Uncertainties in the Fish and Wildlife Program* (Council Document SRG 93-2).

The SRG concluded that a major shortcoming of the fish and wildlife program was that it lacked an explicit conceptual foundation "that couples life histories and production with appropriate ecosystem components." The SRG described the critical ecological uncertainties that identify important gaps in knowledge of the resources and functional relationships that determine fish and wildlife productivity in the Columbia River ecosystem. The SRG also identified six "ecological uncertainties that encompass the Fish and Wildlife Program as a whole, as opposed to a long list of uncertainties associated with each of the program elements." With some exceptions, the six uncertainties were programmatic in scale. Phrased as questions, the uncertainties are:

1. What are the key assumptions in the fish and wildlife program, and are they scientifically valid?

2. Can salmonid populations in the Columbia River be increased and sustained over the long term, given the multitude of biological, physical, and cultural constraints?

3. Can the diversity of anadromous salmonid stocks be sustained over the long term?

4. What are the relative contributions of habitat loss, harvest, predation, and mainstem passage to reduced riverine survival and production of anadromous salmonids and other fishes targeted in the program?

5. To what extent are hatchery production and supplementation programs detrimental to wild salmonid productivity and stock diversity?

6. To what extent are assumptions in the wildlife part of the Fish and Wildlife Program ecologically sound?

Subsequently, the Council revised the fish and wildlife program and included actions to address the uncertainties, including creation of the Independent Scientific Group (ISG) to provide an ongoing evaluation of the program on its scientific merits. Importantly, the Council made clear

that uncertainties should be used to guide the prioritization and funding of research efforts conducted under the program. To provide for this guidance the Council created the Independent Scientific Review Panel (ISRP) for the purpose of reviewing projects proposed for funding under the program. The Council and NOAA Fisheries also jointly created the Independent Scientific Advisory Board (ISAB) to provide advice to both agencies, and the Council created a separate panel of economists to offer independent economic advice and analysis regarding fish and wildlife issues. This is the Independent Economic Advisory Board (IEAB).

The ISRP recommended in its review of the previous draft research plan (April, 2002), that development of a long-term research plan would be facilitated by a workshop with members of the ISRP, ISAB and IEAB organized to identify critical uncertainties and research recommendations. During February 2003, the ISAB, ISRP, and the IEAB met for a workshop and discussed the elements of the research plan.

The challenge of determining and compiling a definitive list of critical uncertainties and research recommendations was managed in the following way. An initial listing of critical uncertainties and research recommendations was drawn from the prior publications and recent reports of the Council's science review groups (see next section). Members were then polled for what they considered the primary key uncertainties facing the basin. These were then discussed at the workshop, which provided a forum for the cross-pollination of ideas regarding critical uncertainties and research recommendations. One conclusion of the workshop was that many research areas outlined in the ISG's *Return to the River* (1996) were still not being addressed in the basin. Consequently, it was recommended that the list of research items identified at the meeting and in *Return to the River* might provide adequate guidance for an initial research agenda. Thus, the recommendations in this research plan were developed from prior efforts and updated with the current thinking of the three independent science groups. Because the recommendations arise from competing sources, some of them appear to support a particular perspective.

State of the Science Documents

The fish and wildlife program calls for the initiation of projects to review the current state of the science in key research areas. This effort may include the use of reports, surveys, conferences, and journals. The program identifies the ISAB as the body charged with developing a series of reports to survey past research and summarize the state of the science in key areas. In recent years the ISAB and the ISRP have completed several reviews that evaluate the state of the science underpinning specific topics. In light of the timeliness of these reports, and the research recommendations they contain, their findings collectively shaped the profile of research needs addressed in this plan. These reviews include:

Review of Research, Monitoring, and Evaluation Plan for the NOAA-Fisheries 2000 Federal Columbia River Power System Biological Opinion (January, 2003)

Review of Harvest Management (January 2005)

Review of Strategies for Recovering Tributary Habitat (ISAB 2003-2)

Review of Salmon and Steelhead Supplementation (ISAB 2003-3)

Review of the Action Agencies' Draft Estuary Plan (ISRP 2003-13)

Review of Fiscal Year 2004 Pre-proposals for the US Army Corps of Engineers' Anadromous Fish Evaluation Program (ISRP 2003-14)

Review of Salmon Recovery Strategies for the Columbia River Basin (ISAB 2001-7)

ISG Return to the River Report (NPCC 2000-12)

Research Recommendations From a National Perspective

The Committee on Protection and Management of Pacific Northwest Anadromous Salmon was formed in 1992 under the auspices of the National Research Council's Board on Environmental Studies and Toxicology. The Committee was charged with assessing the state of the stocks, analyzing the causes of decline, and analyzing options for management, taking into consideration socioeconomic costs and benefits. The NRC Committee's efforts culminated in the 1996 publication of *Upstream: Salmon and Society in the Pacific Northwest.* Although, this initiative did not focus on research needs per se, it addressed gaps in knowledge, information needs, and scientific uncertainty. Key points from these topics, as well as insights on institutional arrangements, have been included in here and in Chapter I.

In November 2000, the National Science and Technology Council, Committee on Environment and Natural Resources (CENR), released *From the Edge: Science to Support Restoration of Pacific Salmon.* The report was prepared to support President Clinton's Pacific Coastal Salmon Recovery Initiative, initiated in 1999 to help reverse the decline of Pacific salmon. It is important to note that key authors of this report included members of the ISAB. A major element of the initiative was to accelerate the use of Federal science and technology to assist in the conservation of Pacific salmon. The CENR was requested to develop an assessment that identified knowledge gaps and research priorities based on the considerable amount of scientific information already in existence. The report discusses the science needs for remediation, reviews the findings of several management-oriented science summaries for the Columbia River Basin, discusses the role of science in a restoration program, and underscores the importance of monitoring the status of salmon stocks and the magnitude of risk factors. The report also identified six broad categories of relevant and important research that have been under-emphasized in the past. These include:

1. Definition of critical ecosystem features for the full life cycle of salmonid species and stocks.

2. Quantitative definition and assessment of risks (natural and human caused) during upstream, downstream, and estuary/ocean life stages.

3. Clarification of fundamentals of biological diversity in salmon species, races, and stocks.

4. Development of remedial technologies that work with nature rather than replacing it.

5. Clarification of the regional variation in the physical, biological, social, cultural, and economic environments of salmon.

6. Development of quantitative indicators and analytical methods to assess the status of salmon, characterize risk factors, and evaluate out-comes of remediation efforts to improve environmental conditions or reduce risks.

Appendix E. FY 04 Research Projects Profile

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Appendix E. FY 04 Research Projects Profile

Topic	PPID	Title	FY04	FY05
Habitat	BM2002199202604	Investigate Life History of Spring Chinook Salmon and Summer Steelhead in the Grande Ronde River Basin and Monitor Salmonid Populations and Habitat	949,504	949,504
Habitat	BM2002199608300	CTUIR Grande Ronde Subbasin Restoration	190,000	190,000
Habitat	BM2002199701501	Imnaha Smolt Survival and Smolt to Adult Return Rate Quantification	263,246	263,246
Habitat	BM2002199801003	Spawning distribution of Snake River fall chinook salmon	52,000	52,000
Habitat	BM2002199801004	Monitor and EvaluateYearling Snake River Fall Chinook Released Upstream Of Lower Granite Dam	307,176	307,176
Habitat	CG2001000021009	Assess current and potential salmonid production in Rattlesnake Creek associated with restoration efforts	252,884	252,884
Habitat	CP2002000025010	Regional Stream Conditions and Stressor Evaluation	80,000	80,000
Habitat	CP2002000025055	Echo Meadows Artificial Recharge Extended Groundwater and Surface Water Modeling	358,000	-
Habitat	CP2002000025069	John Day Salmonid Recovery Monitoring Program	124,503	124,503
Habitat	CP2002198402100	Protect and Enhance Anadromous Fish Habitat in The John Day Subbasin	447,889	447,889
Habitat	CP2002198506200	Passage Improvement Evaluation	110,551	110,551
Habitat	CP2002199000501	Umatilla Basin Natural Production Monitoring and Evaluation Project	395,129	395,129
Habitat	CP2002199102900	Understanding the effects of summer flow augmentation on the migratory behavior and survival of fall chinook salmon migrating through L. Granite Res.	610,375	356,375
Habitat	CP2002199106100	Swanson Lakes Wildlife Area (SLWA)	265,137	265,137
Habitat	CP2002199206200	Yakama Nation - Riparian/Wetlands Restoration	1,514,545	1,514,545
Habitat	CP2002199404200	Trout Creek Habitat Restoration Project	383,662	383,662
Habitat	CP2002199406900	Estimate production potential of fall chinook salmon in the Hanford Reach of the Columbia River.	248,739	248,739
Habitat	CP2002199705300	Toppenish-Simcoe Instream Flow Restoration and Assessment	205,000	205,000
Habitat	CP2002199801600	Monitor Natural Escapement & Productivity of John Day Basin Spring Chinook	880,000	880,000
Habitat	CP2002200002600	Rainwater Wildlife Area	304,926	304,926
Habitat	HP2001000023074	Lower Columbia River and Estuary Habitat Assessment and Mapping Project	4,000	-
Habitat	IN2001000022050	Habitat Diversity in Alluvial Rivers	30,000	-
Habitat	IS2003199800200	Snake River Native Salmonid Assessment	322,302	320,806
Habitat	IS2003200000900	Logan Valley Wildlife Mitigation Project/ O&M	146,842	146,842
Habitat	IS2003200002700	Malheur Wildlife Mitigation Project	324,690	335,729
Habitat	LC2003199206800	Implement Willamette Basin Mitigation Program	1,320,649	1,003,443

Topic	PPID	Title	FY04	FY05
Habitat	MC2002000024009	Assess Feasibility of Enhancing White Sturgeon Spawning Substrate Habitat, Kootenai R., Idaho	1,060,000	260,000
Habitat	MS2002199102800	Monitoring smolt migrations of wild Snake River sp/sum chinook salmon	350,000	350,000
Habitat	MS2002199107100	Snake River Sockeye Salmon Habitat and Limnological Research	455,756	455,756
Habitat	MS2002199107300	Idaho Natural Production Monitoring and Evaluation	884,640	884,640
Habitat	MS2002199303501	Enhance Fish, Riparian, and Wildlife Habitat Within the Red River Watershed	224,004	224,004
Habitat	MS2002199405000	Salmon River Habitat Enhancement M & E	245,000	245,000
Habitat	WP2001199001800	Evaluate Rainbow Trout/Habitat Improvements Of Tribs. To Lake Roosevelt	358,500	268,500
Harvest Management	LC2003199306000	Select Area Fishery Evaluation Project	1,673,567	1,703,086
Harvest Management	WP2001199404300	Monitor, Evaluate, Research and Model the Lake Roosevelt Fishery	1,046,491	
Hatchery Effectiveness	BM2002000027002	Assess Salmonids in the Asotin Creek Watershed	230,430	230,000
Hatchery Effectiveness	BM2002199700900	Evaluate Potential Means of Rebuilding Sturgeon Populations in the Snake River Between Lower Granite and Hells Canyon Dams	284,350	284,350
Hatchery Effectiveness	BM2002199800702	Grande Ronde Supplementation: Lostine River O&M and M&E	581,215	581,215
Hatchery Effectiveness	BM2002199800703	Facility O&M And Program M&E For Grande Ronde Spring Chinook Salmon and Summer Steelhead	684,454	684,454
Hatchery Effectiveness	BM2002199800704	Northeast Oregon Hatcheries Implementation (ODFW)	206,048	206,048
Hatchery Effectiveness	BM2002199801001	Grande Ronde Basin Spring Chinook Captive Broodstock Program	723,718	723,718
Hatchery Effectiveness	BM2002199801006	Captive Broodstock Artificial Propagation	175,620	175,620
Hatchery Effectiveness	CC2003199604000	Evaluate The Feasibility And Risks Of Coho Reintroduction In Mid-Columbia	2,213,597	2,288,859
Hatchery Effectiveness	CG2001199506325	Yakima/Klickitat Fisheries Project Monitoring And Evaluation (Klickitat Only)	545,773	545,773
Hatchery Effectiveness	CG2001199902400	Bull trout population assessment in the Columbia River Gorge, WA.	159,000	159,000
Hatchery Effectiveness	CP2002000025007	Determine lamprey species composition, larval distribution and adult abundance in the Deschutes Subbasin	107,971	107,971
Hatchery Effectiveness	CP2002000025059	Develop Progeny Marker for Salmonids to Evaluate Supplementation	198,661	198,661
Hatchery Effectiveness	CP2002000025062	Growth Rate Modulation in Spring Chinook Salmon Supplementation	338,859	338,859
Hatchery Effectiveness	CP2002000025093	Characterize Genetic Differences and Distribution of Freshwater Mussels	237,000	237,000
Hatchery Effectiveness	CP2002198902401	Evaluate Juvenile Salmonid Outmigration and Survival in the Lower Umatilla River Basin	306,235	306,235
Hatchery Effectiveness	CP2002199000500	Umatilla Fish Hatchery Monitoring and Evaluation	572,848	572,848
Hatchery Effectiveness	CP2002199402600	Pacific Lamprey Research and Restoration	501,090	501,090
Hatchery Effectiveness	CP2002199506325	Yakima/Klickitat Fisheries Project Monitoring And Evaluation	4,100,251	4,100,251
Hatchery Effectiveness	CP2002199802000	Assess Fish Habitat and Salmonids in the Walla Walla Watershed in Washington	174,250	174,250
Hatchery Effectiveness	CP2002200001900	Tucannon River Spring Chinook Captive Broodstock Program	101,045	101,045
Hatchery Effectiveness	IM2001000021008	Evaluation of the Banks Lake Fishery	419,000	419,000

Topic	PPID	Title	FY04	FY05
Hatchery Effectiveness	IM2001000021029	A cooperative approach to identifying the role of forage quality in affecting physical condition....of mule deer in north central Washington.	250,000	250,000
Hatchery Effectiveness	IM2001199502700	Develop and Implement Recovery Plan for Depressed Lake Roosevelt White Sturgeon Populations.	250,000	250,000
Hatchery Effectiveness	IS2003199405400	Tools for Managing Bull Trout Populations Influenced by Nonnative Brook Trout Invasions	490,750	490,750
Hatchery Effectiveness	IS2003199701900	Evaluate The Life History of Native Salmonids In The Malheur Basin	333,542	333,542
Hatchery Effectiveness	LC2003200001200	Evaluate factors limiting Columbia River gorge chum salmon populations.	263,888	272,860
Hatchery Effectiveness	LC2003200001400	Evaluate habitat use and population dynamics of lampreys in Cedar Creek	204,465	211,417
Hatchery Effectiveness	MC2002000024019	Research, Monitor, and Restore Native Species	143,942	143,942
Hatchery Effectiveness	MC2002198806400	Kootenai River White Sturgeon Studies and Conservation Aquaculture	1,395,000	2,999,000
Hatchery Effectiveness	MC2002198806500	Kootenai River Fisheries Recovery Investigations	951,697	951,697
Hatchery Effectiveness	MC2002199004400	Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation	1,197,873	1,197,873
Hatchery Effectiveness	MC2002199404700	Lake Pend Oreille Fishery Recovery Project	376,000	376,000
Hatchery Effectiveness	MC2002199404900	Improving the Kootenai River Ecosystem	1,970,000	1,614,000
Hatchery Effectiveness	MC2002199500400	Mitigation for the Construction and Operation of Libby Dam	840,000	870,000
Hatchery Effectiveness	MC2002199700400	Resident Fish Stock Status Above Chief Joseph and Grand Coulee Dams	540,000	540,000
Hatchery Effectiveness	MC2002200000400	Monitor and protect bull trout for Koocanusa Reservoir.	62,000	62,000
Hatchery Effectiveness	MS2002000028061	Safety-Net Artificial Propagation Program (SNAPP)	523,000	300,000
Hatchery Effectiveness	MS2002198335003	Nez Perce Tribal Hatchery Monitoring And Evaluation	1,816,000	1,942,000
Hatchery Effectiveness	MS2002198709900	Dworshak Dam Impacts Assessment and Fisheries Investigation	325,019	325,019
Hatchery Effectiveness	MS2002198909800	Idaho Supplementation Studies	990,000	990,000
Hatchery Effectiveness	MS2002198909801	Evaluate Supplementation Studies in Idaho Rivers (ISS)	125,590	128,270
Hatchery Effectiveness	MS2002198909802	Evaluate Salmon Supplementation Studies in Idaho Rivers- Nez Perce Tribe	429,841	429,841
Hatchery Effectiveness	MS2002198909803	Salmon Supplementation Studies in Idaho- Shoshone-Bannock Tribes	240,767	240,767
Hatchery Effectiveness	MS2002199005500	Steelhead Supplementation Studies in Idaho Rivers	589,086	589,086
Hatchery Effectiveness	MS2002199107200	Redfish Lake Sockeye Salmon Captive Broodstock Program	825,638	825,638
Hatchery Effectiveness	MS2002199204000	Redfish Lake Sockeye Salmon Captive Broodstock Rearing and Research	1,612,308	737,242
Hatchery Effectiveness	MS2002199604300	Johnson Creek Artificial Propagation Enhancement Project	923,887	923,887
Hatchery Effectiveness	MS2002199700100	Captive Rearing Project for Salmon River Chinook Salmon	509,000	509,000
Hatchery Effectiveness	MS2002199703000	Chinook Salmon Adult Abundance Monitoring	502,609	401,789
Hatchery Effectiveness	MS2002199902000	Analyze the Persistence and Spatial Dynamics of Snake River Chinook Salmon	205,491	160,491
Hatchery Effectiveness	MS2002200002800	Evaluate Status of Pacific Lamprey in the Clearwater River Drainage, Idaho	82,913	82,913
Hydropower	CP2002000025053	Evaluate bull trout movements in the Tucannon and Lower Snake rivers	202,224	175,487

Topic	PPID	Title	FY04	FY05
Monitoring and Evaluatio	CP2002000025049	Numerically Simulating the Hydrodynamic and Water Quality Environment for Migrating Salmon in the Lower Snake River	107,917	-
Monitoring and Evaluatio	MS2002000028001	Evaluate Factors Influencing Bias and Precision of Chinook Salmon Redd Counts	219,109	219,109
Natural Variation and Ocean Productivity	CE2003199801400	Survival and Growth of Juvenile Salmonids in the Columbia River Plume	1,827,962	1,890,113
Predation	MC2002000024001	Lake Pend Oreille Predation Research	155,000	155,000