Northwest Power and Conservation Council

February 9, 2006

MEMORANDUM

TO: Council

FROM: Steve Waste, Manager Program Analysis and Evaluation

SUBJECT: Approval of Columbia Basin Research Plan

This agenda item seeks the Council's approval of the draft Columbia Basin Research Plan. At the January 2006 Council meeting Dr. Nancy Huntly provided an overview of the joint ISAB and ISRP review of the draft plan, and recommend it be adopted pending completion of the suggested revisions set forth in the review. The Council concurred with this recommendation, and directed staff to make the revisions and submit the plan to the Council for approval at the February meeting.

As part of the revision effort staff met with members of the Anadromous Fish Committee and the Resident Fish Committee of the Columbia Basin Fish and Wildlife Authority (CBFWA). The committees offered several suggested changes that were incorporated into the plan. In essence, the completion of the revisions suggested by the ISAB and ISRP has resulted in many changes in the format of the plan, but only a few changes in substance have resulted from the CBFWA recommendations. It was agreed that staff would continue to work with CBFWA on the implementation of the research plan, by convening a work group that would also include Bonneville to apply the research plan in the context of the Fiscal years 2007-2009 project selection process.

Please note that the draft plan has been organized into an easier to read format and some images have been added for illustrative purpose. It is anticipated that additional graphical and design work will be completed prior to production, but with the Council's approval it is ready for use in the project selection process.

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Columbia River Basin Research Plan

by the

Northwest Power and Conservation Council

February 2006

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I. Introduction

For 25 years, the Northwest Power and Conservation Council (Council) has supported a diverse range of research to pursue the biological objectives of the Columbia River Basin Fish and Wildlife Program (program). Research is necessary to provide scientifically credible answers to questions addressing uncertainties pertinent to management. The term "research" is defined broadly to include parameter estimation, pattern recognition, observation, categorization, the collection of data to better quantify important relationships and processes, hypothesis testing, and improvements in statistical methods.

Research projects implemented under the program, and others in the Columbia River Basin, have advanced scientific understanding of fish and wildlife and their restoration. Despite this concerted effort, critical uncertainties remain and research lacks focus. Consequently, the Council requested development of a Columbia River Basin Research Plan (research plan) in the 2000 Program to guide the development of its research program and to foster collaboration with the research programs of the other resource management entities within the region. (For additional explanation of the context for the research plan see Appendix A.).

Vision Statement

The research plan will inform decision-making and or management actions to conserve and recover native fish and wildlife in the Columbia River Basin by identifying and helping to resolve critical uncertainties

The research plan identifies major research themes and critical uncertainties for research funding. In so doing, the research plan provides guidance for addressing key uncertainties that affect anadromous fish, resident fish, wildlife, and the ecosystems that support them. The research plan will help the Council manage the program by informing decision-making, facilitating scientific review, focusing project selection, providing a basis for redirecting future research, and making the program more effective.

Scope and Audience of the Columbia River Basin Research Plan

The geographic scope of the research plan is limited to the Columbia River Basin. The primary audience for the research plan is policy- and decision-makers responsible for natural resource management within the Columbia River Basin, such as the Council members and regional executives. The research plan will also provide guidance useful to researchers, project sponsors, and planners. The research plan provides a programmatic framework for research under the program and associates the research needed for recovery planning under the Endangered Species Act (ESA) with the broader responsibilities of the program.

In addition to improving implementation of the program, the research plan forges links to the research activity of the many parties that share responsibility for fish and wildlife management in the Columbia River corridor and basin. For example, Bonneville Power Administration (Bonneville) and it's funding of the Council program supports the work of the Army Corp of Engineers, Bureau of Reclamation, NOAA Fisheries, Environmental Protection Agency, and land management agencies (e.g., U.S. Forest Service, U.S. Bureau of Land Management). The tribes, in their role as co-managers, make significant contributions in the areas of harvest management, hatchery production, monitoring, and habitat restoration. The state resource management agencies also play key roles in the implementation of the program (e.g., the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, Idaho Department of Fish and Wildlife, and Montana Department of

Fish, Wildlife, and Parks). The Columbia Basin Fish and Wildlife Authority (CBFWA) represents the fish and wildlife managers of the states and tribes in the Council's program.

II. Objectives

The objectives of the research plan are to:

- Increase accountability for the annual expenditures of research funds
- Improve input from independent scientists, fish and wildlife agencies and tribes, and other interested parties in the region
- Improve coordination among mainstem research programs
- Address critical uncertainties identified in subbasin plans
- Improve monitoring, evaluation, and the application of results
- Improve access to the information generated by the research and restoration projects of the program

The research plan is intended to improve communication among scientists, cooperation among institutions, and better coordination of long-term biological monitoring. A key dialogue that the research plan can facilitate regards the role and use of biological and ecological research to inform decision-making on major conflicts in the basin that have profound sociopolitical implications, such as the persistent disagreements about the relationship of flow and survival of fishes or the influence of hatchery fish on wild stocks. For example, fundamental issues of fish migration and of the interaction of hatchery and wild fish remain poorly understood, yet the consequences are substantial for both listed species and the economy of the region. In fact, the President's Committee on the Environment and Natural Resources stated that, "Basic scientific information is lacking for many of the remedial actions that must be taken over a longer term," (CENR, 2000).

Despite a large body of knowledge about the needs of fish and wildlife, there remain instances in which the region lacks the information to fully understand which mitigation or restoration actions will be most effective. The intent of the research plan is to facilitate prioritization and implementation of research that addresses those uncertainties as they affect anadromous fish, resident fish, and wildlife and the ecosystems that support them. Over time, research completed under the research plan will reduce critical uncertainties by increasing scientifically based knowledge. In sum, the research plan will help the Council manage the program by informing decision-making, facilitating scientific review, focusing project selection, providing a basis for redirecting future research, and most importantly, making restoration projects more effective.

Scientific Principles

In 1998 the Council introduced a set of broad scientific principles and applied these principles to a description of the Columbia River as an ecosystem in the publication Development of a Regional Framework (NPCC 98-16). Subsequently, 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 Columbia River Basin Fish and Wildlife Program, NPCC 2000-19). These principles were derived from a number of reviews and recovery strategies for Columbia River salmon including Return to the River (Williams, 2005) that developed a conceptual foundation for restoration of salmonid fishes in the Columbia River Basin. The scientific principles are grounded in established scientific literature to provide a stable foundation for the Council's program (see section B.2 of the program, Basinwide Provisions). It is intended that all actions taken to implement this program be consistent with these principles:

Principle 1. The abundance, productivity and diversity of organisms are integrally linked to the characteristics of their ecosystems.

Principle 2. Ecosystems are dynamic, resilient and develop over time

Principle 3. Biological systems operate on various spatial and time scales that can be organized hierarchically

Principle 4. Habitats develop, and are maintained, by physical and biological processes

Principle 5. Species play key roles in developing and maintaining ecological conditions

Principle 6. Biological diversity allows ecosystems to persist in the face of environmental variation

Principle 7. Ecological management is adaptive and experimental

Principle 8. Ecosystem function, habitat structure and biological performance are affected by human actions

Other science review groups (National Research Council, 1996; CENR, 2000) have also emphasized the need for an ecosystem perspective as a basis for designing a recovery program for salmon in the Pacific Northwest. Consequently, the science foundation developed by the Council represents an important step in the development of restoration and recovery programs grounded on ecological principles.

III. Implementing the Research Plan

Research will be implemented via two different, but complementary, approaches, the Project Selection Process for Fiscal Years 2007-2009 and a Regional Research Partnership (research partnership). While the research plan is intended to guide funding of research under the Council's fish and wildlife program, it can also help initiate a regional dialogue and guide research policy via the research partnership. The research plan could help launch the research partnership by bringing focus to initial discussions of how best to address research topics that are shared by the Council and other entities. The advantage of this dual approach is that it encompasses the range of research relevant to the Council's program, specifically:

- Research appropriate for the Council to fund
- Research that is funded in part by the Council, is broader in scope than the fish and wildlife program, but is ultimately necessary to reduce the scientific uncertainties impacting the program
- Research that is inappropriate for the Council to fund, but whose findings need to be synthesized to update and inform the conceptual foundation and strategies used in the Council's program

Fish and Wildlife Program Project Selection Process

The research plan identifies general research themes rather than specific issues, in order to provide guidance that will be durable over time. These research themes will be revisited over the next three funding cycles of the program. Thus, the life of the research plan will be nine years, with sequential three-year research, monitoring, and evaluation implementation plans to be developed by a work group comprised of staff from the Council, Bonneville, and CBFWA. The work group would develop a draft implementation plan by following the guidance of the research plan and by drawing from the pool of project proposals approved for funding by the Independent Scientific Review Panel (ISRP). (Consequently, peer review of a draft implementation plan would not be a prerequisite for Council approval, but could be sought if the plan identified gaps that required request for proposals.) The work group will meet initially to draft an implementation plan in support of the program for Fiscal Years 2007-2009. The implementation plan will facilitate implementation of the research plan by:

- Identifying priority uncertainties within the research plan for implementation in the pending funding cycle
- Identifying projects that address these uncertainties
- Being responsive to advancements in science and technology
- Ensuring continuity in data collection

Thus, the critical uncertainties identified in the research plan can serve to inform and shape the research agenda for the region, with the more specific details to be developed over time as the research plan is implemented. For these reasons the research plan is structured as a framework guidance document for decision-makers and executives. The Fiscal Years 2007-2009 project selection process will be used to address priority uncertainties set forth in the research plan, restoration priorities set forth in subbasin plans, and some of the monitoring priorities identified by the Pacific Northwest Aquatic Monitoring Partnership, or PNAMP, (PNAMP, 2002). (For additional explanation of implementation via the project-selection process see Appendix B.)

Interface with Other Research Plans in the Pacific Northwest

The Council recognizes that the status quo for research within the region consists of multiple, separate research plans. These plans make reference to the "need to coordinate" with other similar efforts, but rarely set forth explicit steps to implement such coordination. Consequently, the Council developed the research plan, in part, to enhance current coordination and facilitate future collaboration. This research plan 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. Many of the critical uncertainties identified in other research plans in the region have been incorporated into this research plan. Thus, this research plan identifies research that can be funded directly through the 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.

It is not the intention of the Council to subsume other research programs into the fish and wildlife program and then direct their funding. To the contrary, the Council intends to use program resources to catalyze research requiring long-term commitments (e.g., research supporting the development of a regional approach to monitoring). To the extent possible, the research plan will facilitate the coordination of processes already in place. For example, these other plans include the Federal Research, Monitoring, and Evaluation Plan, Anadromous Fish Evaluation Program, Washington State Salmon Recovery Plan, and the PNAMP Aquatic Monitoring Strategy. (Detailed information about these other plans and programs are not reiterated in this plan to avoid redundancy and any implication that program considerations are independent from these other efforts.) This facilitation will include the convocation of a Regional Research Partnership.

Regional Research Partnership: A Forum for Collaboration

Many other resource management entities share responsibility for research in support of fish and wildlife stewardship within the Columbia River Basin. Challenges to addressing critical uncertainties include how to manage shared responsibility for funding under overlapping mandates and the how to sustain long-term funding commitments to support research. Operating individually, the resource management agencies have been unable to secure the funding commitments necessary to mount and sustain long-term, and/or large-scale field experiments (e.g., at the scale of river subbasins or basins). The convocation of a research partnership is proposed as a vehicle for meeting these challenges.

The research partnership would facilitate the coordination of research within the region, as well as research conducted outside the Columbia River Basin that is of high relevance to the management of the program. The research partnership would provide a forum for Council involvement in discussion of how best to coordinate research that belongs to others (e.g., federal programs that are implemented in states represented on the Council). To ensure the research partnership is a manageable size, the membership would be comprised of those entities that conduct a research program or fund research within the region, and not include the multiple parties that receive research funds from those same entities. The research partnership would facilitate the coordination of research within the Columbia River Basin by:

- Eliminating redundancies
- Facilitating collaborative projects
- Redirecting savings to new research priorities
- Improving communication among scientists, cooperation among institutions, and coordination of long-term biological monitoring

The Council is well positioned to co-sponsor a collaborative regional research program that encompasses the entities involved in fish, wildlife, and hydrosystem mitigation in the Columbia Basin. In particular, the Council's membership, structure, and processes (e.g., open public meetings and hearings) provide opportunities to facilitate coordination among the parties funding research programs. The effort to inaugurate the research partnership could be staffed by the Council until such time that it becomes sufficiently organized to have the members provide support on a rotating basis. CBFWA, Bonneville, NOAA, and the U.S. Geologic Survey have all offered to work with Council staff to help sponsor the research partnership. The initial expectations for the research partnership should be modest, but as its members develop mutual trust over time, the partnership could become a useful vehicle for negotiating and advancing on a regional research agenda. (Further explanation of the research partnership is provided in Appendix C.)

Monitoring and Data Management in Support of Research

Implementation of the research plan will require administrative support in two key areas: monitoring and evaluation, and data management. The fish and wildlife program will draw support on monitoring issues from PNAMP, whose mission is to coordinate existing individual monitoring programs into a regional approach that can provide a basis for evaluation at the programmatic scale. (For more details see Appendix D.).

The Northwest Environmental Data Network (NED) is concurrently working with StreamNet and others to develop a regional data standards program to support regional data networking. The program will draw support on data management issues from NED and StreamNet. The development of a regional data management partnership is a concept for which Council sponsored projects and support have already provided significant substance (see Appendix E.).

Even if the three partnerships are only semi-formal in an administrative sense, and only loosely coupled in a decision-making sense, the synergy that could result from linking research, monitoring and evaluation, and data management could significantly increase the ability of the region to re-direct its efforts based on the cumulative results of the projects within the program.

Specifically:

- The research partnership would increase the ability of the region to reduce scientific uncertainty
- The monitoring partnership would support the programmatic evaluation of the program
- The data partnership could develop a data repository for analytical manipulation of data at the programmatic scale

To succeed, the research program must institutionalize accountability at the programmatic scale, and therefore must be closely coordinated with PNAMP and NED. It will be essential to make the results of these initiatives available to the region. This could be accomplished by the publication of a "Columbia River Basin Journal" which could provide a vehicle for disseminating results of program actions and as a forum for advancing regional knowledge. (For additional explanation see Appendix F.)

Relationship to Subbasin Plans

In 2000, the Council initiated subbasin planning to help local entities develop fish and wildlife restoration plans. In 2004 and 2005, 57 subbasin plans that identified needs and opportunities for restoration were adopted into the fish and wildlife program. The cooperative and inclusive participation of federal, state, tribal, and local stakeholders in subbasin planning created the opportunity for stakeholders to collectively address the critical uncertainties within a subbasin. A staff review of the subbasin plans found that a minority

explicitly identified critical uncertainties. Those uncertainties were incorporated into topic-specific tables that will support the implementation plan for Fiscal Years 2007-2009.

Yet many subbasin plans did not include research or monitoring strategies, and few addressed larger-scale conservation and restoration (e.g., at the provincial or basin scale), indicating the need for coordinated planning to ensure that research is implemented that addresses uncertainties relevant to a majority of subbasins. The results of proposed research projects should have broad application to other provinces, or to the basin as a whole, irrespective of where they are located. Consequently, research projects that address the critical uncertainties identified in the research plan and that will potentially help multiple subbasins will be given preference in the project selection process.

IV. Focal Research Themes and Critical Uncertainties

The research plan divides important scientific critical uncertainties into 12 focal research themes. The research plan provides a regionally agreed-upon list of these critical uncertainties, but does not include extensive background beyond that necessary to establish the significance of each topic. The critical uncertainties are described at a high level so that the research plan can provide long-range guidance while preserving flexibility of implementation in the near-term. The critical uncertainties are presented in general terms to elicit the development of specific research hypotheses and project proposals without constraining innovative approaches. The critical uncertainties were synthesized from the fish and wildlife program, reports of the Independent Scientific Advisory Board (ISAB) and the ISRP, regional fish and wildlife managers, subbasin plans, national science groups, biological opinions, and other research plans within the region (see Appendix G.).

(1) Hatcheries/Artificial Production

It is estimated that over 83 million fish were released from hatcheries in the Columbia River Basin in 2004 (FPC, 2004). Many hatcheries operate within the basin and have diverse purposes (e.g. the culture and release fish of salmonids, white sturgeon, and largemouth bass). Hatchery uncertainties are therefore partitioned by purpose (as defined in the APR/Council Document 99-15): the uncertainties of supplementation and captive rearing for conservation and preservation; and the uncertainties of conventional production for harvest and reintroduction. The proportion of hatchery fish harvested in the various fisheries has not been determined.

Artificial production is authorized under many congressional mandates, and the Council funds only a modest portion of total hatchery production. The purposes of artificial production include conventional production to mitigate for hydrosystem construction and operation by providing harvest for commercial, sport, and tribal fisheries; conservation of depleted (often ESA-listed) populations using supplementation, captive rearing, and captive broodstocks; and reintroductions of species (e.g., coho and fall Chinook) into subbasins where they have been extirpated.

It is recognized that using artificial production to provide a harvest opportunity carries with it a cost of increasing the risk of extinction or extirpation of naturally spawning independent populations. The Council's 1999 Artificial Production Review defined principles for use of artificial production in the basin, beginning with determination of the purpose of each hatchery program by an Artificial Production Review Evaluation (NPCC 2004-17). An urgent need remains for fundamental information on the interactions of hatchery-produced fish with wild populations (Williams, 2005; CENR, 2000; NPPC, 99-15; NPPC, 99-4; 2000 Columbia River Basin Fish and Wildlife Program, ISAB, 2003-3).

The essential issue for hatcheries now is to determine the balance of their effectiveness and their hazards. Specifically, how detrimental are the releases from "segregated" mitigation and harvest augmentation programs to wild fish, owing to ecological interactions and interbreeding, and how detrimental are the supplementation programs to target and non-target natural populations from ecological interactions and interbreeding? The question of hatchery impacts on natural production extends from local and stock-specific interactions to interactions within large-scale mixed-stock fisheries over very large spatial and temporal scales. Moreover, there are expected limitations of the hatchery approach, and integration with other approaches begs better understanding. The Council's 2000 Program recommends that supplementation and habitat restoration be linked with the goal of reestablishing self-sustaining natural salmon populations and explicitly directs an experimental approach to all hatchery projects (page 29, 2000 Fish and Wildlife Program).

Critical Uncertainties:

Conventional Hatchery Production—

1. What is the cost to natural populations from competition, predation (direct and indirect), and disease caused by interactions with hatchery-origin juveniles and from harvest in fisheries targeting hatchery-origin adults?

2. To what extent can interactions between production-hatchery fish and naturally produced wild fish be reduced (e.g., with the goal of achieving sustainable long-term productivity and resilience of the wild component of the population by spatial or temporal partitioning of natural and artificial production at the subbasin, province, basin, and regional scale)?

Supplementation—

3. What is the magnitude of any demographic benefit to the production of natural-origin juveniles and adults from the natural spawning of hatchery-origin supplementation adults?

4. What are the range, magnitude, and rates of change of natural spawning fitness of integrated (supplemented) populations, and how are these related to management rules, including the proportion of hatchery fish permitted on the spawning grounds, the broodstock mining rate, and the proportion of natural origin adults in the hatchery broodstock?

5. Can the carrying capacity of freshwater habitat be accurately determined and, if so, how should this information be used to establish the goals and limitations of supplementation programs within subbasins?

All Hatcheries—

6. What is the relationship between basinwide hatchery production and the survival and growth of naturally produced fish in freshwater, estuarine, and oceanic habitats?

7. What effect do hatchery fish have on other species in the freshwater and estuarine habitats into which they are released?

(2) Hydrosystem

Construction and operation of the hydrosystem have caused extensive changes in the Columbia River Basin, including major alteration of the riverine environment such as slow-moving reservoirs, mainstem habitat degradation, power-peaking fluctuations in flow, elevated temperatures, and barriers to migration. Therefore, the fish and wildlife program emphasizes research in mainstem operations, including spill, flow augmentation, and fish transportation. Passage standards, objectives, designs, and evaluations, must be related to increases in adults returning to spawning grounds (juvenile-to-adult survival rates), not just the incremental survival of juveniles or adults through the Columbia River hydropower system.

Technologies that most closely approximate the natural physical and biological conditions of migration most likely would accommodate diverse species life histories, and multiple passage systems are likely needed to fully protect all species. For example, surface bypass systems take advantage of the tendency for yearling smolts to pass dams near the surface and other passage systems, such as screens and turbines, are used to pass fish which move lower in the water column.

River operations significantly different than the status quo need to be tested to provide information for resolving key uncertainties about the hydrosystem impacts on fish. There is considerable uncertainty about the effects of changes in river flows, spill, and water quality on the migratory behavior of juvenile and adult fish. There is a need to determine the effects of mainstem flow manipulation on survival through experimental studies of all aspects of flow manipulation, including load following (see ISAB, 2003-1). For

instance, determining the effects on migration of 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 greater opportunity for power generation than current procedures. The secondary effects of flow differences on near-shore habitat conditions of present-day reservoirs (temperature, flow, and food production) and effects of shoreline modifications along reservoirs (riprap, erosion, and permanent sloughs) also need to be evaluated. Additionally, recent studies on out-migrating juvenile fall Chinook indicate that they have a more complex migratory life history than previously thought, calling into question the estimated juvenile survival through the hydrosystem and the current use of transportation, spill and flow augmentation to protect fall Chinook (ISAB, 2004-2).

Previous large-scale analytical assessments (Peters and Marmorek 2001; Karieva et al. 2000; Wilson 2003) evaluated management options for halting the decline of the Snake River stream type chinook populations. These results depended on whether the source of mortality that takes place in the estuary and early ocean is related to earlier hydrosystem experience (delayed mortality) during downstream migration. Substantial evidence supports the existence of delayed mortality for Snake River Chinook salmon and links that delayed mortality to their earlier hydrosystem experience (Budy et al. 2002).

Critical Uncertainties:

1. What is the relationship between levels of flow and survival of juvenile and adult fish through the Columbia Basin hydrosystem? Do changes in spill and other flow manipulations significantly affect water quality, smolt travel rate, and survival during migration? How do effects vary among species, life-history stages, and migration timings? What is the role of hydrodynamic features other than mid-channel velocity in fish migration? What is the relationship between ratios of transport and inriver return rates and measurements of juvenile survival (D values)?
2. Under what conditions is delayed mortality related to a fishes downstream migration experience and the magnitude of that delayed hydrosystem mortality?

Photo by Max Bian

Bonneville Dam

3. What are the effects of multiple dam passages, transportation, and spill operations on adult fish migration behavior, straying, and pre-spawn mortality, and juvenile-to-adult survival rates?

4. What is the effect of hydrosystem flow stabilization, flow characteristics, and channel features on anadromous and resident fish species and stocks? What are the ecological effects of hydrosystem operations on downstream mainstem, estuarine, and plume habitats and on populations of fish and wildlife?

5. What are the optimal temperature and water quality regimes for fish survival in tributary and mainstem reaches affected by dams, and are there options for hydrosystem operations that would enable these optimal water quality characteristics to be achieved? What would be the effects of such changes in operations and environment on fish, shoreline and riparian habitat, and wildlife?

(3) Tributary and Mainstem Habitat

Degradation, loss, and fragmentation of habitat have contributed substantially to the depletion of fish and wildlife populations in the Columbia River Basin. Fish and wildlife habitat has been severely degraded by dams and diversions, sedimentation from forestry and agriculture, and the introduction of nonnative species. Native fish and wildlife are sustained by complex and interconnected habitats, which are created, altered, and maintained by natural physical processes. Restoration efforts must focus on restoring habitats and habitat connectivity and on developing ecosystem conditions and functions that will support diverse species.

The 2000 Fish and Wildlife Program places importance on improved natural habitat for fish spawning and rearing throughout their life cycle, including tributary, estuary, and marine stages. The critical ecosystem features for the full life cycle of salmonid species and stocks must be defined (CENR, 2000), and the dynamic relationships between habitat and fish and wildlife productivity must be better understood to conserve and restore fish and wildlife populations. A comprehensive life-cycle approach that addresses both natural variability in environmental conditions and human impacts on physical, chemical, and biological processes affecting fish and wildlife populations must be defined (ISAB, 2003-2).

Several critical knowledge gaps must be addressed. The Interior Columbia Basin Ecosystem Management Project was largely limited to federally managed lands, and the Council should support a similar initiative to assess the status of habitat throughout the Columbia River Basin, as this information is essential in developing a sound, basinwide restoration strategy. The rate of habitat loss should be quantified, and locations of habitat loss and restoration should be inventoried and evaluated to assess how well the current and projected habitat template supports the life history needs of fish and wildlife. The effectiveness of present best man-

Photo by Rick Williams

The Upper Imnaha River

agement practices and restoration techniques must be resolved by scientific evaluation at both site-specific and watershed scales. Finally, little is known about the food webs in the Columbia Basin, especially in the tributaries (e.g., how have they been altered by land and water use, by the introduction of toxics and of non-native plants and animals, by harvesting, and by climate change). Scientific understanding of the role of nutrients in the growth of juvenile salmon in freshwater and estuarine conditions is also incomplete, but fewer adult salmon returning to spawn in many streams has resulted in decreased import and transport of nutrients such as nitrogen and phosphorus.

Critical Uncertainties:

1. To what extent do tributary habitat restoration actions affect the survival, productivity, distribution, and abundance of native fish populations?
2. Are the current procedures being used to identify limiting habitat factors accurate?
3. What are the impacts of hydrosystem operations on mainstem habitats, including the freshwater tidal realm from Bonneville Dam to the salt wedge? How might hydrosystem operations be altered to recover mainstem habitats?
4. What pattern and amount of habitat protection and restoration is needed to ensure long-term viability of fish and wildlife populations in the face of natural environmental variation as well as likely human impacts on habitat in the future?

(4) The Estuary

The Columbia River estuary constitutes the physical and biological interface for fish as they move between their freshwater and ocean life stages. Juvenile anadromous fish rear and undergo adaptation to marine conditions in the estuary, and rearing locations, seasonal timing, residence timing, and migration pathways differ between species and stocks. Wetlands and tidal channels are important rearing habitats for some fish. The Columbia River estuary also provides important rearing habitat for other marine animals and year-round habitat for estuarine species.

The estuary has been impacted by habitat development and management locally, and upriver. Changes in biological processes range from alteration in the food web to the exclusion of fish from large portions of the tidal marshes. Changes in seasonal flows following the development of the hydrosystem have resulted in changes to estuarine circulation, sedimentation, and biological processes. Although all of the anadromous fishes flow through this unique environment, the effects of restoration projects in the estuary have not been evaluated and many basic biological functions of the estuary in the life cycle of fish remain poorly understood. Monitoring of the physical environment, such as that currently under way by the Oregon Graduate Institute, and evaluation of large-scale manipulations of estuarine habitats can be combined to better understand

Photo by Christina Craft

Great Blue Heron

the role of the estuarine environment and its degradation or restoration in the success or failure of salmonid populations (ISRP, 2003-13).

Critical Uncertainties:

1. What is the significance to fish survival, production, and life-history diversities of habitat degradation or restoration in the estuary as compared with impacts to other habitats in the basin? How does this partitioning of effects vary among species and life-history types?

2. What are the highest priority estuarine habitat types and ecological functions for protection and restoration (e.g., what are most important habitats in the estuary for restoring and maintaining life-history diversities of subyearling Chinook and chum salmon, and how effective were past projects in restoring nursery/feeding areas)?

3. What specific factors affect survival and migration of species and life-history types of fish through the estuary, and how is the timing of ocean entry related to subsequent survival?

(5) The Ocean

Recent research has established that global- and regional-scale processes in the ocean and atmosphere can influence the production of anadromous species such as salmon, lamprey, and cutthroat trout, as well as the structure and dynamics of marine ecosystems. Natural variation in these processes must be understood to correctly interpret the response of fish to management actions in the Columbia Basin.

The marine survival of juvenile fish, and their growth rates and age and size structures, are linked to local and regional processes in the North Pacific Ocean. Salmon abundances in the California Current region (off Washington, Oregon, and California) and in the Gulf of Alaska (Alaska Current) may respond in opposite ways to shifts in climatic regime. For example, during periods of a strong low pressure in atmospheric circulation over the North Pacific Ocean in winter (Aleutian Low), zooplankton production and early marine survival of juvenile salmonids generally increase in the Alaska Current and decrease in the California Current. Climatic phase shifts characteristic of the strong Aleutian Low regime occurred from about 1925 to 1946 and after 1976/77; both periods were marked by precipitous declines in the coho salmon fishery off Oregon. Opposing cycles of salmon abundance between the Alaska Current and the California Current regions underscore the importance of stock-specific regulation of ocean fisheries. In 1999, a phase shift in the Victoria climate pattern and sea surface temperature seems to have influenced productivity of the California Current more than the Alaska Current. As a result of favorable marine conditions in both the California and Alaska currents, the total production of salmon in the eastern North Pacific and Gulf of Alaska reached an all-time high in the early 2000s.

Photo by Richard Foote

The Pacific Ocean

While the marine production of salmon can be tied to major oceanic and atmospheric circulation, salmon life cycles are shorter than the inter-decadal periods of large-scale climatic change, and short-term climate change phenomena such as the El Nino-Southern Oscillation also can have a strong influence on freshwater and marine survival of salmonids. Thus, the ability to predict adult salmon returns in the face of both short-term and long-term climate change is critical to harvest management and recovery of depressed stocks of Columbia River salmonids. While the abundance of salmonids is known to track large- and small-scale shifts in climate, the specific mechanisms of biological response are poorly understood. Decadal and interannual cycles of ocean productivity have the potential to mask changes in the survival of salmon during freshwater phases of their life cycle, confounding interpretation of the performance of restoration efforts and increasing losses of some stocks. There is also increasing evidence that ocean fisheries on groundfish (Pacific whiting, walleye, pollock, halibut, etc.) and coastal pelagic species (squid, sardines, anchovies, etc.) may affect salmonids through food web interactions. Stocks with different life history traits and ocean migration patterns may be favored under different combinations of climate and more local conditions, and such differences may afford stability to salmon species in the face of environmental variability. Conservative standards for harvest, hatchery practices, and freshwater habitat protection may be necessary even during periods of high ocean productivity to maintain the genetic diversity needed to withstand subsequent troughs in productivity.

Critical Uncertainties:

1. Can stock-specific data on ocean abundance, distribution, density-dependent growth and survival, and migration of salmonids, both hatchery and wild, be used to evaluate and adjust marine fishery interceptions[1], harvest, and hatchery production in order to optimize harvests and ecological benefits within the Columbia River Basin?
2. Can monitoring of ocean conditions and abundance of salmon and steelhead during their first weeks or months at sea improve our ability to predict interannual fluctuations in the production of Columbia Basin Evolutionarily Significant Units (ESUs) or populations to enable appropriate changes to harvest levels?
3. How can interannual and interdecadal changes in ocean conditions be incorporated into management decisions relating to hydrosystem operations, the numbers and timing of hatchery releases, and harvest levels to enhance survival rates, diversity, and viability of ESA-listed salmonids?
4. What are the effects of commercial and sport fishing on ocean food webs?

(6) Harvest

Harvest management for many fish populations in the Columbia River Basin has substantially changed due to state and federal listings. Harvest for listed populations is managed under biological opinions that attempt to ensure fisheries do not pose jeopardy to listed fish species. Most current harvest management targets fish from mitigation hatcheries; productivity to support harvest has been largely divorced from production in natural habitat.

The ISAB Harvest Management Review (ISAB, 2005-4) addressed the question: what constitutes a sound scientific basis for the management of Pacific salmonids in the Columbia River Basin? The report also noted critical uncertainties as to the effect of harvest on the conservation of naturally produced salmonids, including the fundamental need to better monitor and understand mixed-stock fisheries. Three fundamental components of harvest management were identified

1 Interceptions are catches of juvenile, immature, or maturing fish by non-target fisheries.

as causes of concern: a paucity of quantitative data for analyses by population units; limited identification and assessment of the catches of hatchery and wild stocks to identify trends in their status and provide a biological basis for production goals; and limited evidence of accounting for uncertainty in management plans.

Critical Uncertainties:

1. What are the effects of fishery interceptions and harvest in mixed-stock areas, such as the ocean and mainstem Columbia, on the abundance, productivity, and viability of ESUs or populations, and how can fishery interceptions and harvests of ESUs or populations, both hatchery and wild, best be managed to minimize the effects of harvest on the abundance, productivity, and viability of those ESUs and populations?

2. What new harvest and escapement strategies can be employed to improve harvest opportunities and ecological benefits within the Columbia Basin while minimizing negative effects on ESUs or populations of concern? Can genetic techniques be used to quantify impacts on wild or ESA-listed stocks in ocean fisheries?

3. How can the multiple ecological benefits that salmon provide to the watersheds where they spawn (e.g., provision of a food resource for wildlife and a nutrient source for streams and riparian areas) be incorporated effectively into procedures for establishing escapement goals?

Photo by Daniel Vedamuthu

Fishing boats along the Oregon coast.

(7) Population Structure and Diversity

Fish and wildlife populations are characterized by life history, ecological, behavioral, phenotypic, and genetic diversity, which buffer populations against short- and long-term environmental variation. For anadromous salmonids, stock diversity has been reduced by the extinction of many local populations, as well as a reduction in population size of most remaining populations. Moreover, losses of genetic diversity within populations may have decreased fitness and therefore decreased the probability of long-term persistence for many stocks. A better understanding is needed of the dominant processes influencing the distribution, interconnection, and dynamics of populations through time and space.

Additionally, populations are a fundamental unit of viability analysis, and effectively evaluating the status of a species may depend on correctly understanding its population structure. Identification of strong, weak, and at-risk native populations is a critical step in determining what actions can be taken to preserve and protect populations (see ISAB, 2001-7). Several species (e.g., resident and anadromous rainbow, ocean and reservoir type fall Chinook) have co-occurring life-history types that are poorly understood and pose critical problems for management.

Critical Uncertainties:

1. What approaches to population recovery and habitat restoration are most effective in regain-

ing meta-population structure and diversity that will increase viability of fish and wildlife in the Columbia River Basin?

2. How do artificial production and supplementation impact the maintenance or restoration of an ecologically functional metapopulation structure?

3. What is the relationship between genetic diversity and ecological and evolutionary performance, and to what extent does the loss of stock diversity reduce the fitness, and hence survival rate and resilience, of remaining populations?

(8) Effects of Climate Change on Fish and Wildlife

Variation in climate and ocean conditions are now recognized as major contributors to fluctuations and trends in fish and wildlife abundance. Global climate change may interact with shorter-term climate patterns to accentuate these effects on fish and wildlife. In the Pacific Northwest, reduced ocean survival of salmon and stressful freshwater conditions, due to low precipitation, low stream flow, and high stream temperatures, tend to be concurrent. The changes in regional snowpack and stream flows in the Columbia Basin that are projected by many climate models could have a profound impact on the success of restoration efforts and the status of fish and wildlife populations. Nevertheless, climate change is rarely incorporated into natural resource planning. Additionally, the cumulative effects of human development of the Basin may become apparent only when climatic conditions trigger a dramatic response.

Critical Uncertainties:

1. Can integrated ecological monitoring be used to determine how climate change simultaneously affects fish and wildlife and the freshwater, estuarine, ocean, and terrestrial habitats and ecosystems that sustain them?

2. Can indices of climate change be used to better understand and predict interannual and interdecadal changes in production, abundance, diversity, and distribution of Columbia Basin fish and wildlife?

3. What long-term changes are predicted in the Columbia River Basin and the northeast Pacific Ocean, how will they affect the fishes and wildlife in the region, and what actions can ameliorate increased water temperatures, decreased summer river flows, and other ecosystem changes?

(9) Toxics

Toxic contaminants need to be evaluated by the fish and wildlife program, as toxics could negate much of the good work being accomplished in the basin. Toxics have been recognized as a problem since bald eagles and osprey, which eat fish from the river that contain various contaminants, were almost eliminated from the Columbia Basin by the mid-1970s. Reproduction continues to be adversely affected by DDE in a portion of the Columbia River osprey population. Many of the legacy contaminants (e.g., DDE, PCBs) have been declining for years, but new emerging contaminants are taking their place as contaminants of concern. Flame-retardants polybrominated diphenyl ethers (PBDEs) are one group of special concern in the Columbia River. Based upon data from the upper Columbia River, PBDE concentrations in fish are doubling every 1.6 years, and PBDEs have been found in bald eagle eggs from the lower Columbia River and in all 15-osprey eggs sampled from Puget Sound in 2003. Many other emerging contaminants, including modern pesticides and pharmaceuticals, need to be investigated. An adequate toxics monitoring and research program needs to be developed as a coordinated effort of various agencies and groups, including the Council.

Critical Uncertainties:

1. What is the distribution and concentration of toxics, including emerging contaminants, in the Columbia River Basin, and what are/have been their trends over time?

2. How do toxic substances, alone and in combination, affect fish and wildlife distribution and abundance, survival, and productivity?

(10) Invasive Species

Invasive species[2] comprise one of the most significant alterations of native ecosystems and are rapidly becoming a dominant component of ecosystems within the Columbia River Basin (Office of Technology Assessment, 1993). For instance, a recent survey found 81 nonnative aquatic species below Bonneville Dam[3] and, although the impacts of non-native fish stocked for recreation are widely recognized, many other non-native plants and animals also could have a large impact on aquatic habitat and productivity (e.g., Eurasian milfoil, New Zealand mud snail, zebra mussel, Japanese knotweed, Himalayan blackberry, giant reed, and riparian-associated animals such as livestock). Non-native species affect native fish and wildlife both directly (e.g., as predators or competitors, or indirectly, by altering food webs, water chemistry, physical habitat attributes). Some of the most challenging long-term management problems involve nonnative, invasive species, such as the widespread rainbow and brook trout, which were introduced to provide angling opportunities. Intentional introductions of taxa have proven just as likely to cause harm as unintentional introductions (Office of Technology Assessment, 1993).

Additionally, there is conflict between the value of fish passage restoration for native species and the chance that such passage may allow non-native species, such as New Zealand mudsnails, crayfish, other nonnative fishes (e.g., Atlantic salmon), and new diseases, to spread. Thus, there is a need for better assessments of the biological and economic consequences of invasions, including research to identify patterns and consequences of invasions on species and ecosystems. Initial baseline information and monitoring are necessary to detect trends in abundance of non-native and invasive species, and targeted research on invasives is required to better understand the structural and functional changes in ecosystems, habitats, and food webs that they cause.

There have been relatively few examples of success in eradicating well-established invasive species at an ecosystem level. Prevention of introduction and detection of new introductions are therefore essential. A proactive approach to anticipating invasions and identifying areas at-risk could potentially save many millions of dollars in future efforts to control species once they become established and threaten native flora and fauna. Research is needed to identify pathways of introduction and related preventive actions that can reduce the risks of introduction and spread of non-native species.

Critical Uncertainties:

1. What is the current distribution and abundance of invasive and deliberately introduced nonnative species (e.g., the baseline condition), and how is this distribution related to existing habitat conditions (e.g., flow and temperature regimes, human development, restoration actions)?

2. To what extent do (or will) invasive and nonnative species significantly affect the potential recovery of native fish and wildlife species in the Columbia River Basin?

3. What are the primary pathways of introduction of invasive and nonnative species, and what methods could limit new introductions or mitigate the effects of currently established invasives?

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2 For the purpose of this plan, invasive and native species are defined as, as follows: “invasive species” means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health, and “native species” means a species that historically occurred or currently occurs in an ecosystem, without being the result of an introduction. (Section 1 of Presidential Executive Order 13112 Invasive Species).

3 www.clr.pdx.edu/projects/cr_survey/index.tm

(11) Human Development

Like climate change, the impact of human population growth in the Columbia Basin is widely recognized, but is rarely incorporated into fish and wildlife planning. The human population of the Columbia Basin is increasing rapidly, a trend that is expected to continue. This increase is largely concentrated in and around urban areas, but affects non-urban areas as well, through recreation, housing, and changing land uses. At the same time, the economy of the region is shifting, with the potential for both positive and negative impacts on fish and wildlife and their habitats. The Council's program and the NOAA Fisheries restoration plans do not include consideration of human population trends. The fish and wildlife program mitigates human impacts on fish, wildlife, and their habitats, and it is important to consider demographic and economic trends and their potential impacts on efforts to restore and recover fish and wildlife resources.

Critical Uncertainties:

1. What changes in human population density, distribution, and economic activity are expected over the next 20 years? 50 years?

2. How might the projected changes under different development scenarios affect land use patterns, protection and restoration efforts, habitats, and fish and wildlife populations?

(12) Monitoring and Evaluation

Adaptive management, using scientifically well-informed management actions and information drawn from their implementation, is recognized as essential to effective implementation of the fish and wildlife program. Adaptive management requires monitoring and evaluation, including status and trend monitoring of fish, wildlife, habitats, and ecosystems, and action effectiveness research, to provide information with which to evaluate project outcomes relative to project objectives and programmatic standards. Monitoring contributes needed information to address whether biological and programmatic performance objectives established within the fish and wildlife program (e.g., subbasin plans and mainstem amendments; FCRPS BiOp; and ESA Recovery Plans) are being met; how current management should be changed to better meet those objectives; what factors are limiting ability to achieve performance standards or objectives; and what mitigation actions are most effective at addressing the limiting factors. This research plan identifies four critical monitoring and evaluation needs, listed below, in addition to the need to support additional monitoring priorities and programs as a collaborative partner in a Regional Research Partnership.

Some priority research topics require a monitoring program for answers. For example, supplementation has significant critical uncertainties that require extensive and coordinated monitoring to resolve (ISRP and ISAB, 2005-15). This can be addressed by coordination of supplementation projects across the Columbia River Basin so that, in aggregate, they constitute a basinwide adaptive management experiment that includes un-supplemented reference streams. Thus, an initial monitoring and evaluation priority will be to address the following four critical uncertainties:

Critical Uncertainties:

1. What are the range, magnitude, and rates of change of natural spawning fitness of integrated (supplemented) populations, and how are these related to management rules, including the proportion of hatchery fish permitted on the spawning grounds, the broodstock mining rate, and the proportion of natural-origin adults in the hatchery broodstock?

2. Can a common probabilistic (statistical) site selection procedure for population and habitat status and trend monitoring be developed cooperatively?

3. Can a scientifically credible trend monitoring procedure based on remote sensing, photography, and data layers in a GIS format be developed?

4. Can empirical (e.g., regression) models for prediction of current abundance or presence-absence of focal species concurrent with the collection of data on status and trends of wildlife and fish populations and habitat be developed?

The last three uncertainties were identified as key steps for building a foundation to address critical monitoring needs of the fish and wildlife program, as well as to support the coordinated monitoring and evaluation needs of other regional research and management programs, see ISRP Retrospective Report (ISRP, 2005-14).

There are a number of existing efforts in the region to coordinate and collaborate around monitoring and evaluation, but until recently there has been a lack of an organizing principle or central forum to facilitate these efforts. In 2005, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) was chartered to provide such a forum. As members of PNAMP, the Council, Bonneville, and the fish and wildlife managers are working to implement the fish and wildlife program within the context of a regional network of monitoring effort so that the shared monitoring needs and objectives of the program can be achieved. The Council has directly supported this work through the Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) to assure and facilitate implementation within the Columbia Basin. In close coordination with PNAMP, the CSMEP has been working since October 2003 to develop rigorous approaches to monitoring and evaluation that directly serve the needs of specific decisions, and build on the strengths of existing monitoring infrastructure. PNAMP and CSMEP have been, and will continue, working closely together.

V. Appendixes

Appendix A. Context for the Research Plan

Objectives of the Council's Fish and Wildlife Program

This appendix provides additional explanation of the rationale for the research plan. In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act[4] 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."*

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 monitors the program, which is funded by the Bonneville and implemented by tribal, state, and federal fish and wildlife managers and others. The Council adopted the first fish and wildlife program in November 1982. The latest revision of the program, in 2000, marked a significant departure from past versions, which consisted primarily of a collection of measures directing specific activities. In contrast, the 2000 Program establishes a basinwide vision for fish and wildlife along with four overarching biological objectives:

- A Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife
- Mitigation across the basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem
- Sufficient populations of fish and wildlife providing abundant opportunities for tribal trust and treaty right harvest and for non-tribal harvest
- Recovery of the fish and wildlife affected by the development and operation of the hydrosystem that are listed under the Endangered Species Act

Mandate for the Research Plan

Critical uncertainties have persisted for years because the relevant research questions are difficult to answer due to: environmental variability; the complexity of the Columbia River Basin environment; and the inherent difficulty in agreeing on specific problem definitions. In addition, over the course of the development of the program, the Council adopted specific measures for research without a research plan to provide clear prioritization of the remaining critical uncertainties. Without a research plan it was difficult to focus on those uncertainties, and so in the 2000 Program the Council called for development of a Columbia River Basin Research Plan. The plan will guide the development of a research program and foster collaboration with the research programs of other resource management entities within the region. Specifically, the Basinwide Provisions (D.9) state that:

> *"The Council will establish a basinwide research plan, similar to the subbasin plans, which identifies key uncertainties for this program and its bio-*

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

logical objectives and the steps needed to resolve them. The plan will identify major research topics, including ocean research, and establish priorities for research funding."

Appendix B. Implementing the Research Plan in Fiscal Years 2007-2009

This appendix explains the methods by which research project proposals were solicited; reviewed by the ISRP; and, evaluated against decision criteria for identifying priorities.

It includes a table depicting the conceptual framework for a regional approach to research, monitoring, and evaluation and describes how the research plan will be implemented in Fiscal Years 2007-2009.

Project Selection Process for Fiscal Years 2007-2009

The Project Selection Process for Fiscal Years 2007-2009 provides a vehicle for implementing research that is central to the program (i.e., supports the mitigation and restoration of wildlife, resident fish, unlisted anadromous fish, and listed anadromous fish). In contrast to the Fiscal Years 2004-2006 funding cycle, the Fiscal Years 2007-2009 process will have benefit of the priorities set forth in the research plan, subbasin plans, the PNAMP Aquatic Monitoring Strategy, and NOAA Recovery Planning documents. Furthermore, the authors of these planning documents have collaboratively developed a framework for implementing a regional approach to research, monitoring, and evaluation, depicted in Table 1, presented at the end of this appendix. These sets of priorities, and the framework, have provided both targets for project proposals and guidance for the review and evaluation of ongoing and proposed research.

The Fiscal Years 2007-2009 project selection process provides an immediate opportunity to begin work on these critical uncertainties. The competing demands on program funding underscores the need for an assessment of proposed research activity in relation to on-going research. Many restoration projects are conducted that contribute to resolving critical uncertainties because they have a research component, but the overall project is not a dedicated research project. Therefore, the implementation of new research may require a reallocation of research dollars during Fiscal Years 2007-2009 and subsequent funding cycles. In many cases, existing projects may provide a strong start for a new research focus (e.g., ongoing projects with strong links to regional research priorities will be considered as vehicles for addressing those priorities).

The fact that there may be multiple ongoing projects addressing a research topic does not preclude an enterprising sponsor from proposing a new or novel approach to the same problem. In the past, the Council has received project proposals submitted in response to solicitations that were geographic in scope; the Council did not actively seek proposals to address specific critical uncertainties. The prior open approach to solicitations 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. In the past the ISAB and ISRP have suggested directing the available research and monitoring resources to a smaller number of projects that are well designed and have the intellectual and financial resources to generate useful information.

Methods of Project Solicitation

The Northwest Power Act affords the Council broad discretion to develop the procedures for conducting project review and selection.

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 process was implemented on a three-year cycle.

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 have helped 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 were free to propose research projects unique to their geographic location but were encouraged to propose research that provides a basis for extrapolation outside of the subbasin in which the project is located. Research projects with basinwide implications should compete with each other in the Mainstem-Systemwide Review, and not be competed against restoration proposals across multiple provincial reviews.

Requests for Proposals

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

Review of Project Proposals by the ISRP

The Northwest Power Act also requires all project proposals to undergo an independent scientific review of specific project proposals by the ISRP to ascertain their scientific and technical merits. 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 specific reference to research priorities. Consequently, this research plan should enable the ISRP to better compare and evaluate projects for relevance to critical uncertainties.

In addition to the ISRP's scientific review, proposals are evaluated within a policy context to determine their potential contribution to management decision-making. The regional fish and wildlife managers provide recommendations to the Council on these matters, and it is essential that they continue their key role in determining which projects are most likely to benefit fish and wildlife, including research projects that may provide the basis for eventual management actions. In summary, the Council's recommendations for Bonneville funding rest on a mix of priorities, legal considerations, technical adequacy, management urgency, regional opportunities, and available funding.

Identifying Projects that Address Research Priorities

Although the research plan addresses overarching research questions, rapidly emerging management uncertainties may arise from time to time that warrant updating the research plan in order to respond to such contingencies by identifying additional research priorities. The ISRP and ISAB recommend developing implementation plans as the appropriate vehicle for implementing the research plan and providing a prioritization for research over each three-year funding cycle. Development of the implementation plans will also include negotiation and determination of the relative importance

of projects to the priorities. The following criteria are proposed for use in identifying priority research in the Fiscal Years 2007-2009 project selection process.

Critical Uncertainties - Projects that address critical uncertainties identified in this research plan will be considered priority projects. The results of such work must have broad application (e.g., provide a basis for extrapolation across ecologically similar subbasins, or provinces).

Time Required, Statistical Power - If the activity is likely to produce useful results within the five- to 10-year timeframe for the biological opinion, it will be ranked higher than one where more time will be required to yield information relevant to management decisions. Activities that yield statistically reliable results given the design of the experiment (duration, type, and intensity of monitoring) will be ranked higher than those that do not. If survival rates are being monitored, the change should be large enough to be important in reducing extinction risks, or increasing the likelihood of recovery.

ESU Significance - Monitoring directed at ESA-listed ESUs will be ranked higher than activities directed at other stocks. For those directed elsewhere, there should be another justification for conducting the activity (e.g., smolt-to-adult returns for Middle Columbia Chinook), to compare the Snake and Upper Columbia stocks. Populations with higher extinction risk or greater requisite increases in survival rates will generally receive higher priorities for both management and research actions.

Cost Feasibility - In prioritizing competing research activities intended to produce roughly the same information, cost of the different activities will be one criterion in selecting projects for funding. Feasibility will also be important. For example, a project may be powerful and well designed, but may be impractical due to logistical constraints (e.g., take permits cannot be issued quickly, customized equipment may take too long to build).

Relationship to Other Research - To what extent does the proposed activity depend on other projects, and to what degree does it build on ongoing, related work? Some projects may conflict with other research. For example, a "control" stock for habitat enhancement cannot simultaneously be a "treatment" stock for nutrient supplementation. These conflicts require resolution before research activities are undertaken.

Innovation - Innovation is a critical element of any large management or research program and should be encouraged. 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. Although innovative project solicitations were not pursued in Fiscal Years 2003-2005, Council members have expressed continued support for an innovative-project category. Although the innovative category is not being used in the Fiscal Years 2007-2009 funding cycle, the cycle still provides an immediate opportunity to fund innovative projects. Given the intractability of some research challenges it is important to keep the spark of innovation alive.

RM&E Management Questions, Information Needs, and Cost Sharing Agencies (BPA 11/14/05)

RM&E Framework Component	Management Questions	Subordinate Questions	Regional Information Needs					
			Metrics	**Data Required**	**Survey or Experimental Design**	**Spatial Scale**	**Temporal Scale**	**Agencies[5] with Cost Sharing Responsibilities**
Tributary Habitat Status and Trend Monitoring	Are Columbia Basin fish populations meeting population level objectives (abundance, productivity, and diversity)?							
		What is size of adult salmonid and resident fish populations?	Numbers of adult fish	Numbers of adults, spawners, or redds	Census or spatially-balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
		What is the distribution of salmonid and resident fish populations??	Presence/absence of adult fishes	Presence of adults, spawners, or redds	Census	Columbia Basin, ESU, Population, Core Area, or Sub-population	Sampling every 3 to 5 years	1st: FR, S, T 2nd: AA, LU
		What is the growth rate of adult salmonid and resident fish populations?	Returns/Spawner, Lambda, Temporal Trends	Numbers of adults, spawners, or redds	Census or spatially-balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual for at least 3 generations	1st: FR, S, T 2nd: AA, LU
		What is the freshwater productivity of these populations?	Smolts, fry or parr produced per adult, spawner, or redd	Number of smolts, fry or parr	Census or spatially-balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
		What is the age structure of these populations?	Age of returning adults or spawners	Otolith, scale, or length of adults or spawners	Census or spatially-balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
		What fraction of the spawners of these populations is of hatchery origin?	Ratio of hatchery to total fish abundances	Number of hatchery produced adults or spawners	Census or spatially-balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU

5 FR= Fish Regulatory Agencies (NOAA and/or USFWS); AA= FCRPS Action Agencies (BPA, COE, BOR); LU= Land Management Agencies (USFS, BLM); EPA= Environmental Protection Agency; S = State Agency; T= Tribe

	Are aquatic, riparian, and upland ecosystems of the Columbia Basin being degraded, restored or maintained relative to desired conditions or objectives?							
		What is the biological condition of spawning and rearing habitat for Columbia Basin fish populations?	Macro-invertebrate and fish assemblages		Spatially-Balanced survey	Stream, watershed, subbasin	Annual sampling	1st: FR, EPA, S, T 2nd: AA, LU
		What is the physical condition of spawning and rearing habitat for Columbia Basin fish populations?	Valley characteristics (valley bottom types, valley widths and gradients, valley containment, road density, land ownership, land use); Channel characteristics (bed-form types, channel types, gradient, width/depth ratio, stability); Riparian vegetation (structure, disturbance, canopy cover); Habitat access (dams and diversions); Stream flows; Habitat quality (substrate, embeddedness, large woody debris, pools, off-channel habitat, fish cover)		Spatially-balanced survey[6]	Stream, watershed, subbasin	Annual sampling	1st: LU, S, T 2nd: AA, FR
		What is the water quality in spawning and rearing habitats for Columbia Basin fish populations?	Temperature, Turbidity, Conductivity, pH, Dissolved Oxygen, Nutrients, Toxic Pollutants and Heavy Metals		Spatially-balanced survey	Stream, watershed, subbasin	Annual sampling	1st: EPA, S, T, LU 2nd: FR, AA

6 Spatially-Balanced Survey Design (e.g., EMAP-GRTS design; see Stevens and Olsen 2004)

Tributary Habitat Action Effectiveness Research	What actions are most effective at addressing the limiting factors preventing achievement of habitat, fish or wildlife performance objectives?							
		Did all tributary habitat actions in aggregate for a sub-population increase juvenile survival or adult abundance, compared to a similar sub-population with few or no habitat actions?	Type, location, timing and intensity of habitat actions, and juvenile survival or adult abundances	Depends on management actions	Large-scale Before-After (BA) Studies [7]	Watershed, Subbasin	Depends on management action(s)	1st: AA, S, T 2nd: FR, LU
		What contribution did all tributary habitat actions for an ESU make toward increasing the ESU-level population growth rate?	Type, location, timing and intensity of habitat actions, and ESU population growth rates	Depends on management actions	Large-scale Before-After (BA) Studies	ESU scale	Depends on management action(s)	1st: AA, S, T 2nd: FR, LU
		Did a single tributary habitat action increase local fish abundance or distribution, or improve local environmental conditions, compared to a similar control or reference site?	Type, location, timing and intensity of habitat action, local fish abundance or distribution, and/or habitat conditions	Depends on management actions	Project-scale Before-After Studies [8]	Stream, Watershed	Depends on management action(s)	1st: AA, LU, S, T 2nd: FR
		Did some classes of actions (e.g., riparian restoration actions) perform better than other classes (e.g., passage improvement actions) in improving localized conditions or sub-population juvenile survival rates?	Type, location, timing and intensity of habitat actions, and local habitat conditions and/or juvenile fish survivals	Depends on management actions	Project-scale Before-After Studies	Stream, Watershed	Depends on management action(s)	1st: AA, S, T 2nd: FR, LU

7 Intensive BA, BACI, or Staircase designs; see Roni et al. 2005

8 Intensive BA, Extensive BA, or replicated BACI; see Roni et al. 2005

Tributary Habitat Uncertainty Research	What are the limiting factors or threats preventing the achievement of desired habitat, fish or wildlife performance objectives?							
		What is the relationship of habitat processes and functions of upslope, riparian, and aquatic systems to biological and environmental habitat attributes?	Watershed condition metrics identified above.	Watershed condition data identified above.	Depends on correlation or experimental approach	Stream, watershed, subbasin	Depends on correlation or experimental approach	1st: LU, S, T, EPA 2nd: FR, AA
		What is the relationship of habitat attributes, processes, and/or functions to fish and wildlife abundance, productivity, and diversity?	Watershed condition and fish population metrics identified above.	Watershed condition and fish population data identified above.	Depends on correlation or experimental approach	Stream, watershed, subbasin	Depends on correlation or experimental approach	1st: FR, S, T 2nd: AA, LU, EPA
Hydro Status and Trend Monitoring	Are salmon and steelhead meeting juvenile and adult hydro passage objectives?	Are smolts achieving survival standards prescibed in the NOAA BOs?	Smolt survival estimates through impounded reaches of the Snake and lower Columbia System survival estimates reflecting delayed effects of transported smolts	PIT tag detection histories through the FCRPS Tagging ample # of fish at hatcheries as surrogates for wild ones. Annual estimates of D	Cormack-Jolly-Seber single release model	LGR to BON tailrace, when possible	Annual	1st: AA 2nd: FR
		Are adults achieving survival standards prescribed in the NOAA BOs?	Survival indices of adult salmon and steelhead through the FCRPS. *NOTE- AFEP funds some, but not all, data elements required under this objective. Close coordination with AFEP required*	PIT detection histories at ladder-based detectors, for known source fish. Estimates of stray rates Estimates of harvest removals of PIT tagged fish in the Mainstem. Estimates of incidental harvest mortality, e.g., net drop out rates, catch and release related mortality, etc.	Accounting of fates for returning PIT tagged fish.	BON to uppermost dam as applicable to an ESU	Annual	1st: AA 2nd: FR

Hydro Action Effectiveness Research	*NOTE- AFEP funds elements required under this objective. Close coordination with AFEP is required.*							
Hydro Uncertainty Research	What is the magnitude of delayed effects associated with transporting smolts?	Under what conditions does inriver passage yield higher SARs than transport?	Estimates of D for wild and hatchery fish	PIT tag detections juveniles and returning adults SAR for transport and inriver groups, i.e. TIR estimates Inriver survival estimates Direct transport survival estimates	Empirical estimates & model derived estimates for populations of some inriver migrants	Individual transport sites to designated return site.	Annual	1st: AA 2nd: FR
		Is transport appropriate for some locations and not others?	TIR estimates for wild and hatchery fish					1st: AA 2nd: FR
	Do smolts migrating through the FCRPS incur delayed effects?	What is the magnitude of such effects?	SARs linked to different smolt passage fates or experiences	PIT tag detections as juveniles to describe migratory experience PIT detections of returning adults	Compare SAR among treatment groups	Variable	One to several years	1st: AA 2nd: FR
		What are the causes and can they be rectified?	Localized smolt survival rates (Identify zones of particularly intense mortality that could depress SAR)	Variety, e.g. PIT, acoustic tag or radio telemetry data from smolts.	Compare survival with reference areas.	Geographically localized, e.g. bird predation centered at islands	One to several years	1st: AA 2nd: FR

Estuary Habitat Environmental Status and Trend Monitoring	Are aquatic, riparian, and upland ecosystems of the estuary (from Bonneville Dam to the mouth of the Col. R.) being degraded, restored or maintained relative to desired conditions or objectives?	Using a hierarchical habitat classification system based on existing hydro-geomorphology, to what quantitative extent are we avoiding further loss to existing shallow water wetland habitat and restoring degraded habitats, in particular for listed salmonids?	Characterization of Vegetation cover, Geology/ soils, Floodplain topography, Bathymetry	Habitat classification	Census (mensurative) or spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What is the amount of habitat in absolute acreage, by habitat type, that was restored annually and by proportion of the total lost historically for each habitat type for each reach of the CRE?	Measurements of Area affected	Habitat classification Habitat condition	Census (mensurative)or spatially balanced survey	BON to mouth	Annually	1st: FR 2nd: AA, S
		What is the index of habitat connectivity by reach and its status/trend?	Connectivity — Inventory of Passage barriers and Total edge, density and sinuosity of floodplain and tidal channels.	Habitat connectivity	Census (mensurative)or spatially balanced survey	BON to mouth	Annually	1st: FR 2nd: AA, S
	What are the status/trends in attributes of the CRE, plume, and ocean ecosystems?	What are estuary habitat physical properties?	Habitat — Characterization of Vegetation cover, Geology/ soils, Floodplain topography, Measurements of Bathymetry	Habitat condition and classification	Statistical (mensurative) or Spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are estuary fish population properties, especially with respect-listed salmonids?	Fish – Estimates of Species composition, Age/size-structure, Stock identity, Temporal distribution, Spatial distribution, Migration pathways, Growth rate, Residence time, Prey availability, Foraging success, Survival rate, Predation index	Life history diversity, spatial distribution, growth, survival	Statistical (mensurative)or spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are estuary hydrograph and water quality properties?	Water — Measurements of Hydrograph, Temperature, Salinity, Dissolved oxygen, pH, Turbidity, Nutrients, Toxics	River discharge, water quality	Statistical (mensurative)or spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are invasive species properties?	Invasives — Invasive species list, Invasive spatial distribution, Invasive abundance	Invasive species assessment	Statistical (mensurative)or spatially balanced survey	BON to mouth	3 yrs	1st: FR 2nd: AA, S
		What are the environmental conditions and salmon ecology in the Col. R. plume and ocean relative to salmon production and survival?	Plume and Ocean — Estimates of Juvenile salmon usage, Growth, Survival, Zooplankton prey base, and Anchovy/ herring index in the plume and Measurements of Sea surface temperature, Northern oscillation index, Upwelling index, chlorophyll	Ocean and plume conditions, Growth, residence time, survival,	Statistical (mensurative)or spatially balanced survey	Plume and N. Pacific Ocean	Depends on metric	1st: FR 2nd: AA, S

Estuary Action Effectiveness Research	What actions are most effective at addressing the limiting factors preventing achievement of habitat, fish or wildlife performance objectives?	What is the cumulative effect of multiple habitat restoration projects on the CRE ecosystem?	See "Connectivity", "Habitat" and "Fish" above	Habitat cond's, habitat connectivity, fauna, life history diversity, spatial dist., growth, survival, predation, water quality physical cond.,	Effectiveness (mensurative) or Large-scale Before-After (BA) Studies	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are the effects of hydrologic reconnection projects (e.g., dike breaches, new tide gates and culverts) and revegetation projects?	See "Connectivity", "Habitat", "Fish" and "Invasives" above	Habitat connectivity, life history diversity, spatial dist., growth, survival, invasive species	Effectiveness (mensurative) or Project-scale Before-After Studies	BON to mouth	Annually	1st: FR, AA 2nd: S
		What possible changes to FCRPS operations might improve habitat conditions in the CRE for Columbia basin salmonids?	Ibid	Ibid	Effectiveness (mensurative) or Large-scale Before-After (BA) Studies	BON to plume	Depends on metric	1st: FR, AA 2nd: S
Estuary Uncertainties Research	What are the limiting factors or threats in the estuary preventing the achievement of desired habitat, fish or wildlife performance objectives in the Col. Basin?	What is the ecological importance of the Columbia River estuary and oceanic plume to the viability and recovery of salmonid populations in the Columbia Basin?	See "Connectivity", "Habitat", "Fish", "Invasives" and "Plume and Ocean" above	Habitat cond's, habitat connectivity, fauna, life history diversity, spatial dist., growth, survival, predation, water quality physical cond., river discharge, plume conditions	Effectiveness (mensurative) or Large-scale Before-After (BA) Studies	BON to plume	Depends on metric	1st: AA 2nd: FR, S
		What are the effects of toxics on salmonids?	See "Fish" above, plus estimates of concentrations and distributions of Toxics	Water quality, life history diversity, spatial distribution, growth	Depends on correlation or experimental approach	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are the causal mechanisms affecting survival of juvenile salmon during their first months in the ocean?	See "Fish" and "Plume and Ocean" above	life history diversity, spatial dist., growth, survival, predationplume conditions	Depends on correlation or experimental approach	BON to plume	Depends on metric	1st: FR 2nd: AA, S
		What is the survival rate by species of juvenile salmonids migrating downstream from Bonneville Dam to the mouth of the Columbia River?	Estimates of smolt survival rates, predation indices	Survival	Cormack-Jolly-Seber single release model	BON to mouth	Seasonally	1st: FR 2nd: AA, S

Hatchery Status and Trend Monitoring	What is the relative proportion of hatchery spawning salmon and steelhead compared to wild fish populations?		Ratio of hatchery fish to total fish abundance	Numbers of hatchery-origin and natural-origin fish on spawning grounds	Develop requisite marking guidelines and proceed with the marking of remaining groups of unmarked fish released from hatcheries to facilitate monitoring of hatchery-origin fish in natural spawning areas	Census or spatially balanced survey	Annual sampling	1st: AA 2nd: FR
Hatchery Action Effectiveness Research	Can hatchery reforms reduce the deleterious effects of artificial production on listed populations, thereby contributing to a reduction in extinction risk for affected natural populations?		Returns/spawner, lambda, temporal trends, or other metrics as determined by experimental design	Numbers of adults, spawners, or redds, or other data as determined by experimental design	Studies of modifiied hatchery practices ("reforms") that involve controlled experiments designed and replicated sufficiently to provide statistically and biologically meaningful results pertinent to multiple programs.	As required by experimental design	As required by experimental design	1st: AA 2nd: FR
	Can properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations?		Returns/spawner, lambda, temporal trends	Numbers of adults, spawners, or redds	Treatment and control studies using existing safety-net programs intended to reduce extinction risk of targeted populations.	Selected populations	Annual	1st: AA 2nd: FR
Hatchery Uncertainties Research	What is the reproductive success of hatchery fish spawning in the wild relative to the reproductive success of wild fish?		Number of offsping produced by hatchery x hatchery, hatchery x wild, and wild x wild matings in natural spawning areas and subsequent adult returns from each type of cross	DNA pedigree analysis	Hatchery/wild reproductive success studies	Selected populations	Annual for 2 or 3 generations	1st: AA 2nd: FR
Harvest Status and Trend Monitoring	What are the boundaries of uncertainty around harvest point estimates?	What are the harvest rates on listed wild fish?	Numbers of adult fish harvested and numbers of adult fish escaping	Dam Counts; harvest estimates; PIT tag detections at dams	Census at Dams; sub-sample in fisheries	Columbia Basin; ESU	Continual during fishery	1st: FR 2nd: AA
Harvest Action Effectiveness Research	Are new selective gear types effective at harvesting?		Catch Per Unit of Effort; Catch related to capital and operating expense	Standardized measures of catch and effort		Columbia Basin; ESU	Continual during fishery	1st: FR 2nd: AA
Harvest Action Effectiveness Research	What is the post-release survival of salmon caught in a mark-selective fishery compared to fish that were not harvested?		Survival rates	Tagging for fish that are caught compared to those not caught	Treatment/ control	Columbia Basin; ESU	Continual during fishery	1st: FR 2nd: AA

Predator Status and Trend Monitoring	What is the impact of predators on juvenile salmonids within the Columbia River Basin?							
		What are the nesting distribution, colony size, and colony productivity for the major avian predators within the Columbia River Basin?	Presence/absence of avian predator colonies, colony size, number of nesting pairs, reproductive chronology, reproductive success rates	Colony location, colony size, number of nesting pairs, timing of reproductive events, reproductive success	Census; statistical sample	Columbia Basin or colony	Annual sampling	1st: AA 2nd: FR
		What are the juvenile salmonid consumption rates of major avian predators within the Columbia River Basin?	Diet composition, consumption rates	On-colony PIT tag deposition rates and detection efficiency, diet samples, bill load observation	Statistical sampling of targeted populations	Columbia Basin or colony	Annual sampling	1st: AA 2nd: FR
		What are the consumption rates of major pisciverous predators in the Columbia River Basin?	Abundance, distribution, diet composition, fecundity consumption rates	Abundance, distribution, diet composition, consumption rates	Statistical sampling of targeted populations	Columbia Basin	Annual sampling	1st: AA 2nd: S
	What is the impact of predators on adult salmonids within the Columbia River Basin?							
		What are the consumption rates of mammalian predators (marine) in the Columbia River Basin?	Abundance, distribution, consumption rates, diet composition	Abundance, distribution, consumption rates, diet composition	Census or statistical sampling	Columbia Basin (BON to estuary)	Annual	1st: FR 2nd: AA, S
Predator Action Effectiveness Research	What are the most effective management alternatives/actions that could be used to reduce the impact of predators?							
		What is the effect of alternative management alternatives/actions used to reduce the impact of avian predators?	% Change in Juvenile Salmonid Survival, % Change in Avian Predation Rate	Colony location, colony size, number of nesting pairs, timing of reproductive events, reproductive success, On-colony PIT tag deposition rates and detection efficiency, diet samples, bill load observation	Large-scale Before-After (BA) Studies	Columbia River, alternate habitat location, or colony	Depends on management action(s)	1st: AA 2nd: FR
		What is the effect of management alternatives/actions used to reduce the impact of pisciverous predators?	% Change in Juvenile Salmonid Survival, % Change in pisciverous Predation Rate	Abundance, distribution, diet composition, fecundity consumption rates	Large-scale Before-After (BA) Studies9	System-wide Columbia Basin	Depends on management action(s)	1st: AA 2nd: S

9 Intensive BA, BACI, or Staircase designs; see Roni et al. 2005

Predator Uncertainty Research								
Wildlife Status and Trend Monitoring								
Wildlife Action Effectiveness Research	What are the species response to the various protec-tion/restoration efforts?	How has the mitigation target species responded to fee title versus conservation easements?	Target species abundance for pre/post protec-tion measure	Numbers of adults by target species	Large-scale Before-After (BA) Studies [10] orProject-scale Before-After Studies [11]	Columbia basin	Depends on management action(s)	1st : S,T 2nd : LU
		How has the mitigation target species responded to various habitat enhancement efforts?	Target species abundance for pre/post enhancement measure	Numbers of adults by target species	Large-scale Before-After (BA) Studies orProject-scale Before-After Studies	Columbia basin	Depends on management action(s)	1st : S,T 2nd : L
Wildlife Action Effectiveness Research								

10 Intensive BA, BACI, or Staircase designs; see Roni et al. 2005

11 Intensive BA, Extensive BA, or replicated BACI; see Roni et al. 2005

Appendix C. Developing New 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 essential to a realistic 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, resulting in repetitive research that generates data of diminishing value.

The National Research Council (NRC) stated that current institutional arrangements in the Pacific Northwest have contributed to the salmon problem and probably will need modification if an understanding of how to include "good science" as part of the institutional arrangement is important (National Research Council, 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.

Further, 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. Although the Northwest Power Act process falls short of the ideal of "power-sharing in the exercise of resource management" (Pinkerton, 1992), it does 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.

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

Regional Research Partnership: A Forum for Collaboration

The Columbia River Basin research plan could provide a starting point for the development of a regional research agenda, by providing a rough framework on which discussion of coordination amongst potential partners can focus. While the research plan does not constitute a complete research agenda for the region, it does provide a framework for developing one, through the identification of potential partners, programs, and funding sources for working on research questions held in common. The disagreement that exists over priorities for research stems from the various different, yet sometimes overlapping, management authorities within the Columbia River Basin and the broad geographic scope of the region. The research plan can help diminish this disagreement by:

- Fostering agreement upon a manageable number of well-chosen priorities
- Stating the priorities in ways that promote effective research solutions
- Providing a means for resolving disagreements on priorities
- Taking advantage of unforeseen research opportunities that arise from advancements in technology and scientific knowledge or are simply facilitated by immediate environmental or social opportunities
- Fostering collaborative research with other entities

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. Executives of the agencies and tribes have tried in the past to coordinate decision-making on various aspects of resource management across the Columbia River Basin. Yet no similar effort has been mandated to coordinate the research agendas of the various management entities. Therefore, this research plan proposes the convocation of Regional Research Partnership as a vehicle for meeting the directives set forth above and making a major step towards meeting the recommendation of the NRC.

Implementing Regional Research Priorities

The role of the Regional Research Partnership would be to update and prioritize currently identified research needs and facilitate coordination of the research efforts of the various state, federal, and tribal agencies to ensure that limited funds are allocated for the most important critical uncertainties. The Council is strongly positioned to convene the Regional Research Partnership as 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). A Regional Research Partnership could help the region move beyond the institutional impediments to coordinating research and provide a forum where researchers could transcend disciplinary and institutional boundaries, cross-pollinate ideas, and find peer support for potentially controversial recommendations. A major challenge for the research partnership would be to develop a programmatic approach for managing research within the region. For example, moving beyond the piecemeal solutions that have undercut the success of past restoration efforts (e.g., design a comprehensive effort to reduce sources of mortality across the life cycle of the salmon). The Regional Research Partnership could foster integration of the currently compartmentalized research agendas and budgets of entities that share common objectives. The fish and wildlife scientists and managers in the region could accomplish this by cooperatively developing the forum and a process for identifying research priorities that address shared critical uncertainties.

The research partnership could be an appropriate forum for organizing the type of multiparty experiments that often have been proposed in ISAB and ISRP

reports, or by the Council itself, such as studies of the flow/survival relationship of juvenile salmonids. Uncertainties related to supplementation, tributary restoration actions, mainstem passage and survival, and other issues have been discussed in many ISAB and ISRP reports. These reports provide suggestions as to how these uncertainties might be addressed. In most cases, it is suggested that answers can best be obtained by coordinated experiments (e.g., the ISAB has suggested a load-following experiment). In sum, the research partnership could provide a venue to support coordinated experiments, by identifying ways to share resources, experience, and expertise; fostering teamwork; and leveraging investments from multiple sources.

Identifying Regional Research Priorities

There will always be more research questions to answer, than there are resources to provide answers. Therefore, research should be focused first on those questions that have the greatest relevance to the region. For example, does a critical management uncertainty apply to single or multiple subbasins, a single population or multiple populations?

Scientists who work with "systems theory" often warn that trying to optimize one component of a complex system like the Columbia River Basin, such as the mainstem, may not necessarily increase the system's overall performance. Furthermore, the current emphasis on mainstem research may not provide the certainty that is sought in relation to the recovery of ESA-listed salmonids. In order to achieve an ecological approach it will be important to maintain a diversity of research activities across the basin that supports anadromous fish, resident fish, and wildlife. The critical uncertainties set forth in the research plan should guide the selection of projects so that the funded projects move the program forward in a defined and consistent way that provides synergy across the projects.

The federal, state, and tribal members of the research partnership should work together to identify shared critical uncertainties. The diverse membership of the research partnership should provide an opportunity for open debate amongst peers and a sense of equity in the outcomes. An initial task will be to develop a set of decision criteria to guide the identification of research priorities. It is anticipated that these decision criteria will be drawn from the prior experience with the internal prioritization processes of the respective members. Four key questions need to be addressed by the research partnership:

- Who should decide the priority of the research agenda?
- How should collaborative experiments be designed and implemented (e.g., cost sharing and other means)?
- Why and how should data be collected, stored, and analyzed?
- Who should be responsible for synthesis and dissemination of the results and identifying management implications?

The research partnership should meet as necessary to identify priorities and develop funding estimates that the members can use to inform their respective budget requests.

Facilitating Programmatic Coordination

Currently, a myriad of entities such as universities, private consultants, tribes, state and federal agencies conduct research within the region, yet the lack of a forum for coordination often results in poor communication between project sponsors. This increases the risks of: duplication of effort and inefficient use of funds; conflict among research project objectives; damage to long-term monitoring sites; and increased intrusive sampling of ESA-listed and sensitive native species. The research partnership could facilitate communication between all researchers working within a specific watershed, so that they are aware of and coordinate

with each other's plans and projects in advance. The research partnership also could facilitate communication between individuals conducting similar research in different locales (e.g., within the Pacific Northwest, or nationally). It could also help identify research projects that complement one another (e.g., multiple treatments of the same question in different locations to increase sample size). Additionally, multiple studies of different issues within a single watershed can share monitoring to provide a more holistic view of the outcomes. Another issue is the coordination of research, and restoration activities, so as not to interfere with ongoing research. Finally, the research partnership could coordinate the compilation of technical information on the best tools for research and monitoring and its dissemination to the region.

Collaborative Funding

In 2000, the Council shifted from an annual project funding cycle to a three-year cycle. Because state and federal agencies remain on an annual funding cycle, it is difficult for them to make long-term funding agreements. Consequently, formal arrangements such as memoranda of agreement (MOAs) may be necessary to secure long-term funding commitments for selected large-scale field experiments (e.g., the MOA between Bonneville and the U.S. Forest Service). In regard to the program, it is important to acknowledge the difficulty inherent in reprogramming existing funds to support additional research initiatives within the available direct-program budget.

Yet the important question is not how much investment in additional research the program might afford, but rather how to develop a comprehensive regional research agenda that can be funded from multiple sources, sustained, and managed to mutually endorsed outcomes. A more systematic and strategic approach to leveraging investment by many parties is warranted. The research plan identifies critical uncertainties that need to be addressed by multi-agency initiatives, cooperative funding agreements, and the sharing of responsibility for implementation.

New large-scale field experiments should be conducted collaboratively via shared funding arrangements with other entities. 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 effect 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; for example, 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.

Some identified research and monitoring needs are currently, or should be more appropriately, the requirement or shared responsibility of federal or state agencies other than Bonneville, under mandates other than the Northwest Power Act. This point is particularly relevant to ESA recovery planning and implementation research needs that are proposed for the Columbia River Basin but have application coast-wide. Discrete elements of the identified research and monitoring present differing degrees of opportunities for regional coordination and shared funding. To succeed, it is incumbent upon the research partnership to develop and implement incentive strategies. Incentives may include funding, regulatory flexibility, or recognition, all of which can work in combination. Thus, there is a need to work cooperatively with entities that represent alternative funding sources and have responsibilities that overlap those of the Council (e.g., Trust for Public Lands and others). The regional entities should recognize that all programs are limited by what they can afford to sustain, but that by working together, all the programs could benefit from focused, coordinated expenditures.

Appendix D. Monitoring and Evaluation

The 2000 Fish and Wildlife Program, Basinwide Provision D.9, states:

> *"The Council will initiate a process involving all interested parties in the region to establish guidelines appropriate for the collection and reporting of data in the Columbia River Basin."*

Consequently, an important objective of the research plan is to encourage the development of an effective and economical approach to long-term monitoring that provides a basis for future programmatic scale evaluations. The Columbia Basin has already developed some of the components of a regional monitoring program (e.g., counts of returning anadromous adults at dams, estimates of number of out-migrating juveniles, harvest estimates, hatchery production, etc.). Yet the program needs to facilitate the development of additional components that are important, including long-term PIT tagging of important populations of anadromous populations, coordinated estimation of spawners or escapement into tributaries by standardized sampling and estimation methods, and standardized habitat and water quality sampling and estimation methods.

In order to effectively implement subbasin, recovery, and conservation plans, it is necessary to follow a logical process and paradigm of Assess, Design, Implement, Monitor, Evaluate and Adaptively Adjust plans and their implementation processes (Figure 1.).

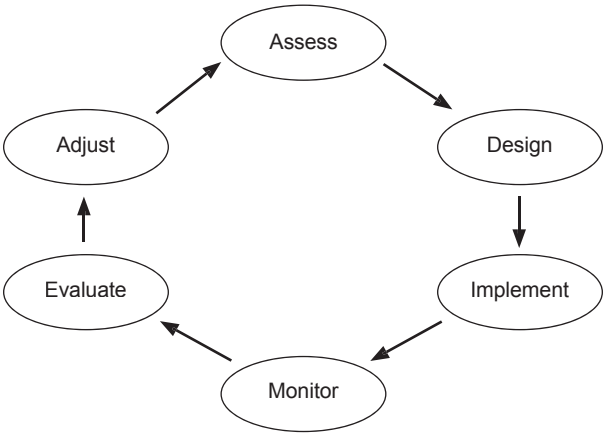

Figure 1. A framework for adaptive management (Nyberg, 1999).

The axiom that "all plans fail at implementation" can be avoided by following the steps toward adaptive management set forth in Figure 1.

- Assessing limiting factors and critical uncertainties
- Designing projects, programs and monitoring to maximize both on-the-ground effectiveness and learning
- Coordinated and documented implementation of projects
- Consistent monitoring through standardized methods, protocols, and training
- Timely and thorough evaluation of effectiveness
- Overall guidance to the region to adjust plans and programs at the province and subbasin level

Monitoring and evaluation are at the heart of adaptive management because they provide the information, data and analysis that decision-makers and resource managers need to track the progress, or lack of progress, of plans and populations. The success of current plans and programs depends on the consistent application of well-designed research, monitoring, and evaluation at multiple scales. These scales range across tributaries with major projects, populations, major population groups, sub-basins, ESUs or Distinct Population Segments, and the entire Columbia Basin. To be useful to decision-makers, a regional approach to monitoring must identify the information required for different types of decisions at each scale (e.g., management of harvests, the hydrosystem, and hatcheries; and decisions on the protection and restoration of habitat).

Evaluating the occurrence and magnitude of trends over time requires a commitment to long-term monitoring (multiple years), and consistent data collection through networks of sites that represent the target population(s) of interest. Substantial research has been

conducted on trend detection (e.g., discussion of form of trend, best tools to detect trend) see Esterby (1993). Yet there has been little discussion in the ecological literature of what constitutes a ‘‘policy-relevant’’ trend and how well we can measure or detect it (Urquhart, Paulsen and Larsen, 1998).

Current Monitoring Activity

Monitoring under the program has primarily been conducted to evaluate work across all subject areas, but at the project scale. This approach has generated information from monitoring individual or opportunistic protection and restoration efforts and the effects of isolated or tactical actions and activities. To advance, the limited resources available for monitoring must be focused on a more programmatic approach that is designed to identify the need for and detect the sum total effect of actions at the population, subbasin, and/or provincial-scale. This can support future analyses of more strategic actions and plans and allow decisions to be made at a higher scale that is population- and ecosystem-based. Finally, performance metrics and high-level indicators can support a programmatic approach to evaluation that can be reported to Congress, the Council and to state, federal, and tribal resource managers (see Figure 2.)

While work at the project scale has intrinsic value and should be continued in many cases, it cannot substitute for the lack of a monitoring program of sufficient scope to provide a basis upon which the program as a whole can be evaluated, and re-directed. Monitoring is required at a number of different scales to assess the performance of the program relative to biological and programmatic objectives, to identify where and why there are performance problems, and to identify the most effective actions needed to correct problems so that program objectives can be achieved. This type of monitoring and evaluation across multiple geographic and temporal scales requires standardized approaches and programmatic, long-term commitments and interconnections for effectively combining information and answering program management questions. The

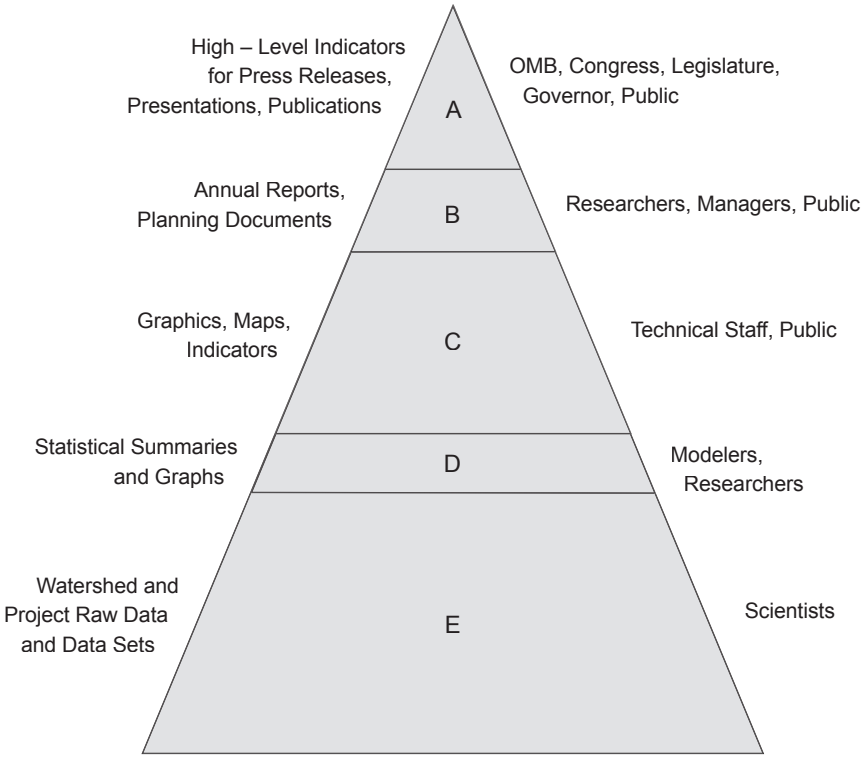

Figure 2. In the monitoring information pyramid, examples of types of information are on the left and related users or generators of that information are represented on the right.

absence of a regionally coordinated approach to monitoring and evaluation in the Columbia River Basin has constrained restoration and planning efforts for decades.

For this reason, it is important that a more hierarchical approach be utilized with increased emphasis on achieving useful outcomes from monitoring. Specifically, methods need to be developed and implemented so that monitoring results can be "rolled up" to provide scientifically defensible evaluations of whether the ecological condition of a subbasin, an ESU, or the Columbia River Basin as a whole is improving or declining over time. This capability would be very useful to policy and decision-makers as they deliberate on future actions that affect the long-term, ecological health of the basin.

Moving monitoring from the project scale to larger spatial scales has both benefits and challenges. One benefit of focusing on the population scale is that it has direct relevance to fish managers, who want to know whether actions upstream of the monitoring location actually improved a fish population's production (e.g., smolts/spawner), in addition to improving habitat conditions in the restored reaches. The population scale is also of great interest to agencies like NOAA Fisheries charged with evaluating the status of listed populations.

There are also some significant challenges at larger spatial scales. Reliably attributing observed changes in fish survival or production to particular sets of management actions requires careful monitoring design. Otherwise, one might erroneously infer that observed changes were due to management actions when in fact they were the result of natural variation in freshwater climate or ocean conditions. Ideally, one would monitor both 'treated' areas (those with habitat restoration actions) and nearby 'reference' areas (those without restoration actions), for several generations of fish populations, both before and after implementation of actions, and measure other explanatory variables simultaneously. One significant challenge in shifting monitoring to larger spatial scales (e.g., populations, subbasins, and provinces), is that at larger scales it becomes increasingly difficult to establish the strong contrasts required to evaluate effectiveness (e.g., areas and times with and without certain classes of restoration actions). For example, adjacent subbasins will each have a variety of implemented restoration actions so that comparing fish production across these subbasins and over time will not lead to any clear inferences on which actions (if any) were responsible for the observed differences in trends over time. It will therefore still be necessary to conduct effectiveness evaluations at finer spatial scales (project to population), for a carefully selected subset of restoration actions and locations in order to generate information of value to the program.

Provincial-scale Objectives and the Need for High Level Indicators

It will be important for the provincial-scale objectives required by the program to encompass a set of core objectives common to the four states, while respecting additional reporting needs of the individual states. The process of developing, negotiating, and gaining regional acceptance of provincial level objectives will be highly analogous to the ongoing efforts of Washington and Oregon. These efforts have been driven either by statutory requirements or by pressure from Congress and Legislatures for accountability. Once established, provincial-scale objectives will provide focus for efforts to develop a regional approach to monitoring that can support evaluation of the overall effectiveness of the program. Figure 2. shows the relationship between types of information and how they how support decision-making. For example, the status of high-level indicators compels the activities at the bottom of the pyramid (e.g., on-the-ground methods, protocols, and logistical implementation requirements). They also can help direct decisions and recommendations about the analytical processes and statistical designs in the middle of the pyramid.

In order to implement adaptive management, resource management agencies need high-level indica-

tors that are easy to understand in terms of every-day definitions and experiences, and yet flow explicitly from on-the-ground monitoring programs providing information on progress towards biological objectives. A subcommittee of PNAMP is currently working to develop a pool of high-level indicators that can be used as the basis for developing provincial-scale objectives that the agencies and tribes of the Pacific Northwest can endorse and implement. Through the coordinated use of high-level indicators, a uniform message about watershed health can be provided with all participating agencies using the same terms and coming to similar conclusions.

Components of a Regional Framework For Research, Monitoring and Evaluation

Through this research plan, the program will contribute to the design and implementation of a coordinated and integrated regional approach to monitoring. Existing regional programs (see Figure 3.) are being networked based on a monitoring framework that is based on:

- Common management questions and information needs supporting the management questions
- Common research, monitoring, and evaluation categories, monitoring designs and protocols that allow the communication and networking of regional programs
- Common understanding on responsibilities and cost sharing of the monitoring needs

The management questions and project category components of this framework are well developed through ongoing regional coordination efforts as set forth in Table 1. It is clear that many of the objectives and management questions of the fish and wildlife program overlap with those of other regional entities and local, state, federal, and tribal governments. The costs of the monitoring and research needed to adequately address these common management questions are more than one program can adequately support or fund alone. Only through the combined efforts of multiple entities can a sufficient level of information be developed to guide these regionally shared resource management decisions through coordinated, standardized and programmatic approaches to monitoring.

The components of the research plan that provide support for the development of a regional monitoring framework are its long-term vision and its organization around biological concepts and management questions. Several other large-scale planning documents support this approach by identifying similar objectives and priorities. Source documents that have contributed to the conceptual foundation of the regional approach include:

- Monitoring Section of ISRP's Retrospective Report – *NPCC 2005*
- Research Plan for the Columbia River Basin – *NPCC 2006*
- Strategy for Coordinating Monitoring of Aquatic Environments in the Pacific Northwest – *PNAMP 2005*
- Considerations for Monitoring in Subbasin Plans 2004 – *PNAMP 2004*
- Conservation of Columbia Basin Fish; Final Basinwide Salmon Recovery Strategy - *Federal Caucus 2000*
- Research, Monitoring, and Evaluation (RME) Plan for the NOAA Fisheries 2000 Federal Columbia River Power System (FCRPS) Biological Opinion - *Action Agencies and NOAA 2003*
- ISAB and ISRP Review of the Action Agencies and NOAA Fisheries' Draft Research, Monitoring & Evaluation Plan for the NOAA-Fisheries 2000 Federal Columbia River Power System Biological Opinion (RME Plan) - *ISAB and ISRP, 2004-1*
- Updated Proposed Action for the FCRPS Biological Opinion Remand - *Action Agencies 2004*

- Proposed Design and Evaluation of Preliminary Design Templates – *CSMEP 2004*
- Data Quality Objectives for Decisions Relating to Status and Trend of Fish Populations, as well as Action Effectiveness of Habitat, Hatchery, Harvest and Hydrosystem Actions – *CSMEP 2005*
- Scope of Work for Implementation of the Northwest Environmental Data Network Project - *Northwest Environmental Data Network 2005*.

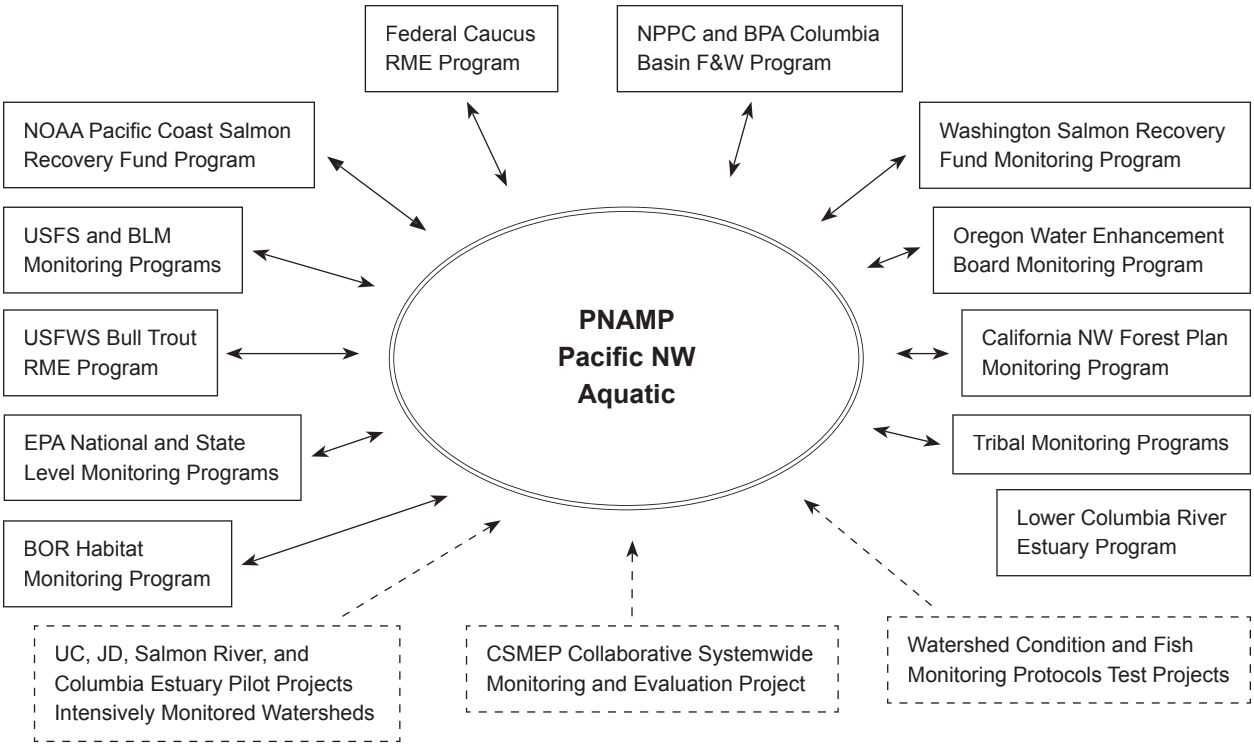

Figure 3. Regional Partnership of Monitoring Efforts.

Appendix E. Data Management

A regional approach to monitoring cannot be achieved without the support of a data management system that can serve as a repository for the data and provide public access, on a timely basis, for analytical manipulation. To be successful a data management system must be able to assist scientists in the identification and development of data standards as it relates to the monitoring of wildlife, resident, and anadromous fish, and their habitats. This objective helps to identify solutions that improve access, sharing, and coordination among different collectors and users of this monitoring data. It also provides a data reporting foundation that could support coordinated agency reporting, uniform monitoring protocols, and improved data quality and quantity. Objectives include:

- Develop a consistent data management methodology within and across each of the types of monitoring
- Establish a close working relationship for data consistency across the data sources
- Identify and document the specific data needs of the region for watershed condition monitoring, fish population monitoring, and effectiveness monitoring
- Develop and recommend data collection standards and information to be shared across the various monitoring programs
- Share requirements and results with regional data networking entities to ensure sharing of monitoring data
- Test the collection protocols, sampling methods and data sharing mechanisms
- Implement coordinated solutions within regional programs
- Incorporate common analytical capabilities and reporting capacity
- Provide public access sections or linked web sites for informational and collaborative processes

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. This initiative is being led by the Northwest Environmental Data Network (NED).

A memorandum of agreement between the Council and NOAA Fisheries guides this initiative, which currently is 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 (ISRP, 2000-3), from independent analysis by Science Applications International Corporation (SAIC, 2003), 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:

- 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

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.)

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. Specific ending dates should be required for project objectives and tasks to help sponsors meet their intended deadlines. Bonneville should enforce its contracts to withhold payment for projects that have not completed the reporting requirement. The final report should be in a form that facilitates review of the results.

Appendix F. Integrating Research Results into Council Policy and Decision-making

Research results must be reviewed and evaluated in order to direct new research and inform on-going work to protect and restore fish and wildlife. The effectiveness of new research results must be evaluated objectively before the results are widely applied (e.g., the removal of log jams, which "impeded" the return of adult salmon to spawn). The review of research results must be conducted across projects and subject areas to determine the contribution of particular results to overall improvements in management. Some tools and metrics for evaluating research contributions across the "H" topic areas and across all life stages of a species were developed and used during subbasin planning. Others are currently being developed under the auspices of PNAMP and through various ESA-related processes. Additional tools and metrics may need to be developed.

Annual workshops sponsored by the Regional Research Partnership could provide a forum for evaluating and disseminating the results of research. 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" (NPCC 2002-3)
- Expanded provincial review presentations
- Workshops structured around single topics driven by specific questions, such as transportation effects, and projects synthesized to address that topic
- Workshops and symposia on emerging topics, such as toxics

These workshops could help assess future research priorities through oral presentations, reporting of results of relevant studies, and the development of scenarios for applying research results in support of management actions. The workshops could promote the exchange of scientific results and provide the Council with information to better inform future funding decisions.

Dissemination of Research Results

The Council will work with the other members of the Regional Research Partnership to develop a strategy for the transfer of research results to other researchers and interested parties.

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 web site to facilitate access. Research reports and data should be made available to scientific collaborators, administrators, and the public for additional analyses. The final reports, and any other products derived from them, should be submitted to the StreamNet Library. This library includes materials relating to the natural resources of the Pacific Northwest and maintains a regional depository of all research projects 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.

The ISRP has recommended that all project proposals reference past achievements and that annual and final reports be issued on time and made available to the region. The ISRP also recommended that "…CBFWA … include in its Annual Implementation Plan a report of past accomplishments at the watershed and subregional/subbasin levels or topical level…." Further, the ISRP has supported publication of evaluations of work conducted under the fish and wildlife program in a

"Columbia River Basin Journal," as a way to disseminate results and provide a forum for advancing regional knowledge on program actions (Fiscal Year 2000 Annual Implementation Work Plan, Vol. I., p. 21). Such a journal could:

- Provide short turn around on the presentation of program results to a regional audience that includes managers
- Provide a common information base to support decision-making by the middle management groups
- Help focus discussion on future directions

Appendix G. Critical Uncertainties

Critical Uncertainties Defined

Critical uncertainties arise from the most important policy issues facing the region. In 1993 the Scientific Review Group (SRG) 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."*

The research plan divides scientifically important, but complex, issues into critical uncertainties. The research plan provides a rationale for why the critical uncertainties are important, but does not include extensive background beyond that necessary to establish significance of the issue. Full syntheses of current knowledge on each research topic are not provided because doing so would require a much longer research plan. The critical uncertainties are described at a high level to preserve flexibility of implementation and to prevent the research plan from quickly becoming dated. The critical uncertainties were compiled from the fish and wildlife program, various reports of the ISAB and the ISRP, regional fish and wildlife managers, subbasin plans, recommendations from national science groups, biological opinions, and other research plans within the region. Chapter IV introduces long-standing and contemporary focal research themes and critical uncertainties important to the program and the region.

By articulating and organizing these uncertainties, the research plan will help the region agree upon research priorities, address knowledge gaps, and avoid duplication of effort. To be effective, the research plan describes the critical uncertainties in terms that are intended to elicit the development of specific research hypothesis and project proposals. Therefore, each research theme profiles the topic and why it is important. This approach highlights the central issues while preserving the challenge for investigators to develop more innovative or integrative approaches. The ISAB and ISRP recommend against an overly detailed rendition of research needs pointing out that it might inadvertently diminish innovative responses; preclude flexibility to incorporate new information and techniques; and result in early obsolescence of the research plan. Further, the ISAB and ISRP cautioned that too many research recommendations could precipitate difficulty in reaching consensus on priorities. Consequently, the inventories of all the potential research topics identified during the public review of the research plan do not appear in the plan, but will be considered during the development of the implementation plan. Taken together, the critical uncertainties set forth in Chapter IV, and the inventories supporting the implementation plan, will provide a framework for guiding more detailed discussions of the allocation of research funding.

Sources of Critical Uncertainties

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 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 (SRG 1993-2).

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 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." The six uncertainties

were programmatic in scale, and are included here in their original form, but phrased as questions:

- What are the key assumptions in the fish and wildlife program, and are they scientifically valid?
- Can salmonid populations in the Columbia River be increased and sustained over the long-term, given the multitude of biological, physical, and cultural constraints?
- Can the diversity of anadromous salmonid stocks be sustained over the long-term?
- 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?
- To what extent are hatchery production and supplementation programs detrimental to wild salmonid productivity and stock diversity?
- 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 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. The Council created the ISRP for the purpose of reviewing projects proposed for funding under the program, and in this role the ISRP provides guidance on prioritizing research. The Council and NOAA Fisheries also jointly created the ISAB to provide advice to both agencies, and now also the Columbia River Indian Tribes. Further background on the science review groups can be found at http://www.nwcouncil.org/fw/science.htm.

Fish and Wildlife Managers

Many valuable recommendations were received from the fish and wildlife managers and other resource management entities and incorporated in the research plan. The fish and wildlife managers are uniquely qualified to help identify research priorities and determine when and where to implement projects. This is an important part of coordinating large-scale planning. The types of comments received ranged from very general points affecting the organization of the document to very specific comments on a particular research topic.

National Scientific Reviews

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 the research plan.

In November 2000, the National Science and Technology Council, Committee on Environment and Natural Resources released From the Edge: Science to Support Restoration of Pacific Salmon (CENR, 2000). 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, including:

- Definition of critical ecosystem features for the full life cycle of salmonid species and stocks
- Quantitative definition and assessment of risks (natural and human caused) during upstream, downstream, and estuary/ocean life stages
- Clarification of fundamentals of biological diversity in salmon species, races, and stocks
- Development of remedial technologies that work with nature rather than replacing it
- Clarification of the regional variation in the physical, biological, social, cultural, and economic environments of salmon
- 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

Public Review of the Columbia River Basin Research Plan

A formal public comment period on the draft Columbia River Basin Research Plan was held from October 1 to November 30, 2004. A total of 28 comments were received from the tribes (three), state agencies (eight), federal agencies (eight), local governments (one), academic institutions (two), consulting firms (four), and private individuals (two). A list of all the entities that provided comments follows.

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