Draft Columbia River Basin Research Plan

NOTE: This DRAFT document has not been reviewed or endorsed by the Council. It is only for internal staff and ISAB and ISRP review.

By the

Northwest Power and Conservation Council

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

Introduction

This Research Plan divides scientifically important, but complex issues, into discrete research questions. By articulating and organizing these questions, the plan will help the region identify research priorities, address knowledge gaps, and avoid duplication of effort. The plan also calls for creating a Regional Research Partnership to set priorities for new investment and judge the relative priority of continued investment in ongoing research. In brief:

Chapter I explains the genesis of the Research Plan and describes the source of the regional research recommendations. It also introduces the concept of the Regional Research Partnership, and provides supporting rational.

In Chapter II, twelve research topics are presented. For each topic the plan provides an overview, a description of management questions, critical uncertainties, a prioritized list of regional research recommendations, and identifies potential collaborators and funding sources to the extent feasible at this time.

In Chapter III, the research priorities identified for each topic in Chapter II are compared to the research projects under the Fish and Wildlife Program to identify knowledge gaps unaddressed by current research. The integration of project results into decision-making and the future evaluation of the research program are also explained.

Northwest Power and Conservation Council

In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act[1] that authorized the states of Idaho, Montana, Oregon and Washington to create the Northwest Power and Conservation Council (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 then monitors implementation of the program, which is funded by the Bonneville Power Administration (Bonneville) and implemented by tribal, state, and federal fish and wildlife managers and others.

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

Mandates for a Columbia River Basin Research Plan

Basinwide Provisions of the Fish and Wildlife Program

The Council adopted the first Fish and Wildlife Program in November 1982. In that plan and in subsequent updates, the Council called for development of a Research Plan but also adopted specific measures for research without clear prioritization of remaining critical uncertainties. The 2000 Program, the latest revision of the program, marks a significant departure from past versions, which consisted primarily of a collection of measures directing specific activities. The 2000 Program establishes a basinwide vision for fish and wildlife along with biological objectives, as noted above, and action strategies that are consistent with the vision. In its vision for the program, the Council states four overarching biological objectives:

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

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

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

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

The heart of the Program is a set of immediate actions to improve conditions for listed and non-listed anadromous fish, resident fish, and wildlife that have been impacted by the hydrosystem in the Columbia River Basin. The Program also calls for the development of a Columbia River Basin Research Plan, henceforth "Research Plan," to identify and resolve key scientific uncertainties. For the purpose of this plan, the term "research" is used broadly and is intended to include more than just dedicated hypothesis testing. For example, "research" may include estimation, pattern recognition, observation, categorization, studies involving the collection of data to better quantify important known relationships, and improvements in statistical methods. Research is necessary to provide scientifically credible answers to questions pertinent to management that are complicated by uncertainty.

The goal of the Research Plan is to address those uncertainties as they affect anadromous fish, resident fish, and wildlife and the ecosystems that support them. Despite a large body of knowledge about the needs of fish and wildlife, there are still instances in which the region lacks the information to fully understand which actions will be most effective. Some research questions in the region have persisted for many years because resource management agencies have been unable to secure, individually or collaboratively, the funding commitments necessary to mount organized, long-range, and/or large-scale field experiments.

The intention of the Council, and the Northwest Power Act, is for the region to make the best possible choice of actions based on the available information. The lack of perfect information is not grounds for inaction.

Recommendations of the Four Governors

Another mandate for developing a regional Research Plan was included in the Recommendations of the Governors of Idaho, Montana, Oregon and Washington for Protecting and Restoring Columbia River Fish and Wildlife and Preserving the Benefits of the Columbia River Power System issued in June of 2003. In regard to research, the Four Governor's Recommendation on Monitoring and Accountability stated: "…the Council, working closely with the States, federal Agencies and Tribes should develop … by year's end, a draft systemwide Research Plan with budgets and priorities."

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

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

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

In order to further the objectives of the Fish and Wildlife Program, this Research Plan will direct research activity in support of fish and wildlife resources in the Columbia River Basin by: identifying critical uncertainties, formulating research recommendations, and identifying priorities for funding.

The plan provides a programmatic framework for research, and associates the research needed for ESA recovery planning with the broader responsibilities of the Fish and Wildlife Program. The Research Plan will help the Council manage the Fish and Wildlife Program by informing decision-making, facilitating scientific review, focusing project selection, and providing a basis for redirecting future research. The Council can help facilitate the coordination of similar research projects within the region to streamline funding, identify and remove unnecessary redundancies, and redirect savings to new research priorities. Over time, research completed under the plan will reduce management uncertainty by increasing scientifically based knowledge.

The objectives of the Research Plan include:

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

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

3. Improved coordination among mainstem research programs.

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

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

6. Improved accessibility of information from the Fish and Wildlife Program.

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 other regional executives. The plan will also provide useful guidance to planners, researchers, and project sponsors. The scope of issues in the plan does not include recounting the factors and events contributing to the decline of fish and wildlife species within the Columbia River Basin, as that history has been described by numerous other sources.

The geographic scope of the Research Plan is limited to the Columbia River Basin, but in addition to supporting the Fish and Wildlife Program, it forges links to the research activity of the Army Corps of Engineers, the U.S. Bureau of Reclamation, Bonneville, NOAA Fisheries, U.S. Fish and Wildlife Service, U.S. Geologic Survey, U.S. Environmental Protection Agency, the Tribes, and other entities.

Background

Past as Prologue

For over 20 years the Council has supported a diverse range of research efforts. Hundreds of excellent projects, including dedicated research projects and habitat restoration projects with research elements, have been completed since the inception of the program in 1982. Projects implemented under the Council's Fish and Wildlife Program and others in the Columbia River Basin have substantially advanced the state of scientific understanding of fish and wildlife restoration. Yet the continuing absence of a plan to coordinate and guide research in the region has contributed to a lack of focus on key research priorities. The Council has drafted this Columbia River Basin Research Plan to guide the development of a research program under its Program, and to foster collaboration with the research programs of the other fish and wildlife management entities within the region.

Many other resource management entities share responsibility with the Council for research in support of fish and wildlife stewardship within the Columbia River Basin. The Council recognized that the status quo for research within the region consists of multiple, separate Research Plans which make reference to the "need to coordinate" with other similar efforts but rarely set forth any explicit steps to implement such coordination. Consequently, a secondary purpose of this plan is to provide a programmatic framework upon which to coordinate research and facilitate the integration of disparate research efforts within the region, e.g., those of regulatory and land use agencies. Key research questions within the region have persisted because of the fragmentation of effort resulting from the inherent difficulty in agreeing on specific problem definitions, and the sharing of responsibility for funding under overlapping mandates. These institutional problems have interfered with taking the next step in addressing key uncertainties, which is determining the feasibility of research needed to address the uncertainties. The key uncertainties have persisted because the questions are difficult to answer due to environmental variability; the complexity of the Columbia River Basin environment; and the challenge of eliciting and sustaining a long-term funding commitments to support research. Now is the time for the Council to set forth an agenda for future research, affirm its support for

research as an element of the Program, and provide leadership for a Regional Research Partnership.

Best Scientific Information

The Northwest Power Act instructs the Council to prepare a fish and wildlife recovery program for the Columbia River Basin that includes measures "...based on, and supported by, the best available scientific knowledge." The Council has sought "the best available scientific knowledge" in different ways as the Fish and Wildlife Program evolved. The Power Act directs the Council to review the program at least every five years, and the Council has done so. With each revision, the Council paid attention to the mandate regarding best available scientific knowledge. In preparing the first version of the program, the Council formed the Scientific and Statistical Advisory Committee to assist in evaluating recommendations for measures to include in the program. In the 1984 Program, the Council created a Fish and Wildlife Committee comprising four Council members and gave the committee duties that included assessing past and present research projects. In the 1987 program revision, the Council created Technical Working Groups consisting of the representatives of agencies, tribes and some other parties. The Technical Working Groups were charged with summarizing existing information and identifying Fish and Wildlife Program research needs in areas such as hatcheries, fish disease and habitat. In 1989, Bonneville and the Columbia Basin Fish and Wildlife Authority (CBFWA) established the Implementation Planning Process for the fish and wildlife program and formed the Scientific Review Group (SRG) as its independent scientific advisory body. The Independent Science Group (ISG) was created by the Council in the 1992 Program, replacing the SRG, to provide advice and to conduct a review of the program that became *Return to the River* (1996). The ISG later evolved into the ISAB and the ISRP.

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

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

Prior Efforts to Identify Research Priorities

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

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

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

In January 2002, Council staff produced a draft Research Plan and requested an ISRP review. On April 15, 2002 the ISRP released its review (Council Document ISRP 2002-4), which recommended a substantial reorganization of the staff's draft plan. The draft plan was not finalized or released but provided a profile of on-going research and helpful information regarding the funding process that was useful in drafting this Research Plan.

Thus in 2003, despite a history of coordination and prioritization efforts, the Council still did not have a Research Plan that identified critical uncertainties and prioritized research recommendations. This is not to diminish the earlier efforts to develop a research plan or identify uncertainties, nor to diminish the excellent research that has been completed in the past at the project scale. Development of this Research Plan should be viewed as an evolutionary progression, as it is now possible to separate some of the broader, vexing uncertainties into more discrete research questions or recommendations. While derivative of the prior efforts, this draft Research Plan is also a continuance of them. In order to succeed, the research program must institutionalize accountability at the programmatic scale, and will therefore be closely coordinated with the initiative of Pacific Northwest Aquatic Monitoring Partnership to develop a regional approach to monitoring.

2005 Columbia River Basin Research Plan

Relationship to Existing Research Plans in the Columbia River Basin

The Council developed the Columbia River Basin 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 research recommendations from other research plans in the region were incorporated into this plan. This plan recommends research to be funded through the Fish and Wildlife Program, as well as recommendations for research that will require collaborative, multi-party funding commitments by the Council and other entities with similar research mandates. To the extent possible, the final Research Plan will link with existing research plans and programs and 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, Pacific Northwest Aquatic Monitoring Partnership, and the Washington State Salmon Recovery Plan. 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.

Sources of Research Recommendations

The research recommendations identified in this plan were compiled from independent science group reports, regional fish and wildlife managers, subbasin plans, recommendations from national science groups, the Fish and Wildlife Program, biological opinions, and other research plans within the region.

Independent Science Groups

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

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

Subsequently, the Council revised the Fish and Wildlife Program and included actions to address the uncertainties, including creation of the Independent Scientific Group (ISG) to provide an ongoing evaluation of the program on its scientific merits. Importantly, the Council made clear that uncertainties should be used to guide the prioritization and funding of research efforts conducted under the program. To provide for this guidance the Council created the Independent Scientific Review Panel (ISRP) for the purpose of reviewing projects proposed for funding under the program. The Council and NOAA Fisheries also jointly created the Independent Scientific Advisory Board (ISAB) to provide advice to both agencies, and now also the Columbia River Indian Tribes.

Unlike the ISRP, that is solely under the Council's purview, the ISAB is jointly sponsored by the Council, NOAA Fisheries, and the Columbia River Basin Indian Tribes. The ISAB provides general scientific advice on recovery efforts whereas the ISRP provides scientific review of specific project proposals. (Further background on the science review groups can be found at http://www.nwcouncil.org/fw/science.htm.) The Council also created a separate panel of economists to offer independent economic advice and analysis regarding fish and wildlife issues, the Independent Economic Advisory Board (IEAB).

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

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

State of the Science Documents

The Fish and Wildlife Program calls for the initiation of projects to review the current state of the science in key research areas. This effort may include the use of reports, surveys, conferences, and journals. The program identifies the ISAB as the body charged with developing a series of reports to survey past research and summarize the state of the science in key areas. In recent years the ISAB and the ISRP have completed several reviews that evaluate the state of the science underpinning specific topics. In light of the timeliness of these reports,

and the research recommendations they contain, their findings collectively shaped the profile of research needs addressed in this plan. These reviews are cited throughout the plan.

Fish and Wildlife Managers

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 is presented in Appendix B.

Many valuable recommendations were received from the fish and wildlife managers and other resource management entities and incorporated in the plan. The fish and wildlife managers are uniquely qualified to help identify research priorities, and determine when and where to implement projects, an important part of the coordination of 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. Where appropriate, the more specific comments were incorporated into the draft by either making the suggested revisions and/or including new text and recommendations.

Subbasin Plans

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

Sound science, thoughtful planning, and hard work on the ground are all important ingredients to the success of any restoration program. Yet without strong local support for restoration activities, the future of many Columbia River Basin species will remain in question. In 2000 the Council initiated subbasin planning in order to help local entities develop their own restoration plans. Subbasin planning has helped people define the future they seek for natural resource values in their subbasins, and thereby define their legacy to future generations.

Subbasin plans have identified coordination needs and opportunities for fish and wildlife restoration by integrating strategies in the Council's Fish and Wildlife Program with other federal, state, tribal, Canadian, and volunteer fish and wildlife restoration programs. The cooperative and inclusive participation of federal, state, tribal, and local stakeholders in subbasin planning created the opportunity for subbasin plans to contain a collective expression of the critical uncertainties and research priorities within a subbasin. Many subbasin plans have identified research needs that are either site specific or a prevalent need within the subbasin or province. The research recommendations in the plan include those set forth in the subbasin plans at the subbasin scale that have broad application. The Research Plan will support research recommendations that have broad application to other provinces, or to the entire Columbia basin.

Thus, in the project selection process for the Fish and Wildlife Program, research projects that can have application beyond a particular subbasin will be given preference.

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 plan.

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

Opportunities for Collaboration: Charting A Course for the Future

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 an essential element of any assessment of where restoration and recovery efforts stand today. This recognition does not impugn the quality of the science conducted in the basin, but it

does help explain why in some cases work of apparently low relevance is continued, while in other cases the application of results of high relevance remains a promise unfulfilled. Further, it explains disparities in the availability of data to support various management alternatives. A common manifestation of this phenomenon is that insufficient information will be available on politically controversial management alternatives.

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

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

Regional Research Partnership

> *A great deal is known about the requirements of salmon, yet much remains unknown, and some gaps in knowledge are crucial to a long-term, stable solution to the salmon problem. Enough is known in the short term to improve the prospects of salmon if knowledge is applied wisely and quickly, but not enough information is known to warrant confidence in a long-term regional plan for salmon….the components of the salmon problem are so diverse that no one person can know all that needs to be known for a comprehensive solution. Thus, the salmon problem is in a sense a cognitive problem whose solution will depend on close cooperation and collaboration of people with many kinds of experience and expertise.* (Emphasis added.)
>
> -- National Research Council, 1996

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

A Forum for Collaborative Implementation and Funding

In the past, attempts have been made to convene executive level multi-agency groups and fora for the purpose of coordinating resource management decision-making across the Columbia River Basin. These unsuccessful efforts indicate that it may not be possible to convene a single "super-group" that can address management decisions across all subject matter areas of resource management in the Columbia River Basin. This is in part due to significant differences between programs in their missions, structures, proposal development, and proposal review processes. The region lacks a regional decision making forum that can arbitrate between competing initiatives to implement the All-H approach. Consequently, this plan simply recommends the convocation of a partnership to foster collaborative research.

A Regional Research Partnership (Partnership) would help the region move beyond these institutional impediments. and provide a forum where researchers can transcend disciplinary and institutional boundaries, cross-pollinate ideas, and find peer support for potentially controversial recommendations. A major challenge for the Partnership is to develop a programmatic approach to managing research within the region. The fish and wildlife scientists and managers in the region would accomplish this by cooperatively developing the forum and a process for identifying research priorities that address key management questions. Further, the Partnership would provide a venue for the identification of ways to share resources, experience, and expertise; fostering teamwork; and leveraging investments from multiple sources.

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

Many of the resource management entities contacted during the development of this Research Plan expressed support for this concept. The Council will convene and host the initial round of meetings to inaugurate the Partnership, as the 2000 Fish and Wildlife Program states that a meeting of fish and wildlife agencies, tribes and hydrosystem operating agencies should be convened regularly to identify key uncertainties about the operation of the hydrosystem and associated mainstem mitigation activities.

Monitoring and Data Management in Support of Research

In order to succeed, the Partnership will require support in two key areas: monitoring and evaluation, and data management. The Partnership could draw support on monitoring issues from the Pacific Northwest Aquatic Monitoring Partnership (PNAMP). The mission of PNAMP is to coordinate existing individual monitoring programs into a regional approach in order to develop a feedback loop that is missing at the programmatic scale. The Northwest Environmental Data Network (NED) is an initiative to deploy a regional data standards program to support regional data networking. The development of a regional data management partnership is a concept for which Council sponsored projects and support have already provided significant substance. (More detail on PNAMP and NED is provided in Chapter II.)

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

Facilitating Programmatic Coordination

Currently, a myriad of research entities (Universities, private consultants, tribes, state and federal agencies) conduct research within the region, yet the lack of an agreed upon mechanism for coordination often results in poor communication among projects. 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 Partnership could facilitate communication between all researchers working within a specific watershed, so that they are aware of, and can coordinate with, each other's plans and projects in advance. The Partnership could also facilitate communication between individuals conducting similar research in different locales. In developing the plan it is important to identify a series of research initiatives that complement one another, e.g., multiple treatments of the same question in different locations to increase sample size. Another approach would be to field multiple studies of different issues within a single watershed that can then share monitoring and provide a more holistic view of the outcomes. In some cases it may also be possible to define a pattern of research that gets at broader questions. Finally, the Partnership could coordinate the compilation and dissemination of information on the best tools for research and monitoring to its members.

Another issue is the coordination of research, and restoration activities, so as not to interfere with on-going research. For example, "replacing" salmon carcasses has been adopted so completely that they are being added to every stream that is accessible by road, independent of whether the addition may affect other research projects or allow an assessment of the effectiveness of the carcass additions. The effectiveness of carcass addition needs to be evaluated or we risk repeating the mistake of taking a good idea and applying it widely before we know whether it is truly good, e.g. the removal of log jams which "impeded" the return of adult salmon to spawn.

Collaborative Funding

In regards to the Fish and Wildlife Program, it is important to acknowledge the difficulty inherent in reprogramming existing Program implementation funds to support additional research initiatives, within the available direct program budget. This is not a question of how much investment in additional research BPA can afford, or the Program can sustain, on behalf of the region; 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 likely warranted.

The Research Plan identifies research priorities that need to be addressed by multi-agency initiatives, cooperative funding agreements, and the sharing of responsibility for implementation. The marshaling of this effort will have implications for the Council's work plan.

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 BPA, under mandates other than the Northwest Power Act. This point is particularly relevant to ESA recovery planning and implementation research needs that are a composite of the requirements jointly managed by several agencies. Discrete elements of the identified research and monitoring present differing degrees of opportunities for regional coordination and funding opportunities. In order to succeed, it will be incumbent upon the Regional Research Partnership to develop and implement incentives strategies. Incentives are not just about funding, but also include regulatory flexibility and recognition, all of which can work in combination.

A Forum for Identifying Regional Research Priorities

The federal, state, and tribal members of the Regional Research Partnership will work together to identify regional research priorities. The diverse membership of the Regional Research Partnership should provide an opportunity for open debate amongst peers and a sense of equity in the outcomes. An initial task of the partnership 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 and internal processes prioritization processes of the respective members. The Partnership will meet as necessary to identify priorities and develop funding estimates that the members can use to inform their respective budget requests. Council staff will convene and host the meetings of the Partnership until such time as the members elect to do otherwise.

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 application across the basin. For example, does the question answer a critical uncertainty for a single subbasin or can it be applied across multiple subbasins? Does the question have the likelihood of improving the status of a single population or will it help multiple populations? Research should also focus on questions that have a large potential increment of benefit. In order to achieve an ecological approach it will be important to maintain a diversity of activities across the basin and among anadromous fish, resident fish, and wildlife. The identified research priorities should guide the selection of projects so that the funded projects move us forward in a defined and consistent way that provides synergy across the projects.

In the past, the science agenda for the Columbia River Basin has suffered from agency research being selected from lists that include research needs of significant interest to those participating in the selection process. A Regional Research Partnership can help preclude the potential for conflict of interest by providing a forum for a broader consideration of the relevance of research priorities to the understanding of aquatic ecosystems, restoration of habitats, recovery of populations, the status of resident, introduced, or invasive species, etc.

Recommendation: Policy makers such as the Council members and regional executives should

foster cooperation of the currently compartmentalized research agendas and budgets of entities that share common objectives, by tasking the Regional Research Partnership to identify and implement research priorities.

II. Research Recommendations for the Columbia River Basin

Organization of Research Topics

Chapter II introduces twelve long-standing and contemporary research topics important to the Fish and Wildlife Program and the region. The topics are profiled using a common format comprised of an overview, management questions, critical uncertainties, a prioritized list of regional research recommendations, and a description collaborators and funding sources. The overview provides a brief synthesis of the issues related to the topic and past research efforts. The management questions arise from the most critical policy issues facing the region and help shape the research recommendations.

Critical Uncertainties

In 1993 the Scientific Review Group defined critical uncertainties:

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

Council Document SRG 93-2 and the report of CENR (2000) each identified six critical uncertainties that still persist today. Of these twelve, eight were topic specific and are presented in their respective section of critical uncertainties. The remaining four address cross-topic uncertainties and are restated below.

Because the uncertainties under the different topics arise from a variety of sources, they lack a clear organizing principle, or conceptual framework for organizing specific research recommendations. Yet consider that the Council's Fish and Wildlife Program is primarily directed at the restoration of fish and wildlife populations. These populations need restoration because mortality rates have increased due to a variety of factors. To the extent appropriate, the critical uncertainties for each topic have been organized under three general questions addressing mortality factors. Although, the questions are stated at a high level and therefore generalized, if it were possible to answer each one of them we would have the understanding to significantly improve resource management in the Columbia Basin.

1. What are the current sources and magnitudes of fish and wildlife mortality? Answering this would help us understand the current status of the resources and where the likely areas of future research will be most fruitful.

2. What are the most effective techniques and activities that can be used to modify the sources and levels of fish and wildlife mortality and improve access to other benefits? Answering this tells us what we need to do in order to achieve improvements.

3. What is the level and pattern of mortalities that is consistent with long-term survival and utilization of fish and wildlife resources? Answering this tells us where we need to go if restoration and recovery efforts are to succeed. This is a general question that integrates across all sources of mortality. It is closely tied to issues of variation in ocean survival, climatic variation, acceptable levels of total mortality, etc.

These questions provide a general structure for organizing the research topics: across the fish and wildlife program by resource category e.g., anadromous fish, resident fish and wildlife; and across research subtopics.

Several public comments suggested organizing the research recommendations by life history stages. This approach would be valuable if quantitative analyses were developed to evaluate how Program activities could improve various stages of the salmonid life cycle , as it would provide decision makers with a prioritization framework for research linked to estimated gains in population productivity. However, the Program manages much more than just anadromous fish, and so the utility of such an approach may be high for some species and low for others with a less differentiated life history.

Identification of Research Priorities

In this draft plan, the research recommendations for each topic are organized by appropriate subtopics, and are presented in order of priority as determined by Council staff. However, before the plan is finalized, it is the expectation of the Council that the prioritization of the research recommendations will be revised, based on the recommendations of the Regional Research Partnership.

Implementation Scenario

Each profile ends with an implementation scenario describing the programs and partners best positioned to initiate work on the top research priorities through the commitment of expertise and/or funding. To the extent possible at this time, the implementation scenarios outline who, how, when, and where the research will be conducted. In this section, research recommendations that appear beyond the scope of the Fish and Wildlife Program are identified for collaborative treatment by a team of members of the Regional Research Partnership with shared or overlapping mandates For research within the purview of the Program competitive and open project solicitations will be utilized as well as Request for proposals.

The critical uncertainties and research recommendations listed in this Plan were developed using the organizing principles listed below to the extent possible. This Plan is a living working document and changes will be made on a regular basis. Further revisions of the plan should follow these organizing principles:

- The critical uncertainties need to be clearly described and related to one of the three mortality elements that we have been using.

- There needs to be at least one research recommendation for each critical uncertainty.

- There should not be any research recommendations that do not relate to a critical uncertainty.

- The research recommendations should be at an appropriate level of detail – neither too broad

Hatcheries

Overview: There is an urgent need for fundamental information on the interactions of hatchery-produced fish with wild populations (Return to the River, 1996; CENR, 2000, NPPC 99-15, NPPC 99-4, 2000 Columbia River Basin Fish and Wildlife Program). Effects of hatchery-produced fish on wild stocks potentially include genetic alteration, competition, predation, and disease. Sufficient attention must be given to evaluating ecological interactions, so that it will be possible to determine whether the intrinsic biological attributes of the species being supplemented, biotic interactions, or habitat limitations constrained the anticipated increases in natural-origin adult recruits. Many hypotheses and conjectures concerning supplementation are largely unevaluated. (For the purpose of this plan, relevant terms such as "stock, population, etc." are defined in Appendix A. Definition of Hatchery Terms.)

The Council's 2000 Program recommends that supplementation and habitat restoration should be linked, with the goal of reestablishing self-sustaining natural salmon populations. Although research has demonstrated detrimental effects of some hatchery programs on wild salmon, hatcheries, if operated properly, may be important and useful tools for restoring salmon populations. Wild stock information, such as the degree of hatchery introgression, is difficult and expensive to acquire, particularly at the stream reach level. Yet if we are to use wild stocks for recovery hatcheries, or to set aside wild stock sanctuaries for future uses, this type of information must be obtained. Geneticists should be employed to develop broodstock collection, spawning, rearing and acclimation/release protocols that will eliminate or reduce the detrimental effects of hatchery programs.

Present - A critical issue facing the region is whether artificial production activities can play a role in providing significant harvest opportunities throughout the basin while also acting to protect and even rebuild naturally spawning populations. In essence, Columbia River Basin supplementation projects are being used to reduce near term management risk, yet may be precipitating long term biological risks. In recent years three major reviews have been critical, and the science on this issue is far from settled. In 1999 the Artificial Production Report (Council Document 99-15) set forth ten policies to guide the use of artificial production as follows:

1. The purpose and use of artificial production must be considered in the context of the environment in which it is used.

2. Artificial production remains experimental. Adaptive management practices that evaluate benefits and address scientific uncertainties are critical.

3. Artificial production programs must recognize the regional and global environmental factors that constrain fish survival.

4. Species diversity must be maintained to sustain populations in the face of environmental variation.

5. Naturally spawning populations should be the model for artificially reared populations.

6. Fish managers must specify the purpose of each artificial production program in the basin.

7. Decisions about artificial production must be based on fish and wildlife goals, objectives and strategies at the subbasin and basin levels.

8. Because artificial production poses risks, risk management strategies must be implemented.

9. Production for harvest is a legitimate management objective of artificial production. But to minimize adverse impacts on naturally spawning populations, harvest rates and practices must be dictated by the need to sustain naturally spawning populations.

10. Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

Many of these points were reaffirmed in the Artificial Production Review and Evaluation issued in 2004 (Council Document 2004-17). The third report is the ISAB Review of Salmon and Steelhead Supplementation (ISAB 2003-3). An important criticism from the ISAB's supplementation report is that inadequate replication and widespread failure to include un-supplemented reference streams, coupled with a lack of coordination among projects, make it uncertain whether such projects will be able to provide convincing quantification of the benefits or harm attributable to supplementation. However, the published literature includes examples of theoretical and empirical studies in the area of hatchery program risks and benefits, which have advanced our understanding of hatchery programs and conservation. Some of the key findings include:

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

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

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

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

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

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

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

Because current monitoring and evaluation efforts are inadequate to estimate either benefit or harm from ongoing supplementation projects, it is important to establish reference populations and adequate levels of monitoring and evaluation as part of the basinwide adaptive management experiment. Specifically, multiple supplementation projects should be coordinated across the Columbia River Basin so that in aggregate they constitute a basinwide adaptive management experiment, maximizing the information collected and attempting to reduce uncertainty. For example, the Idaho Supplementation Studies project includes controlled supplementation with hatchery-origin fish as well as natural production control areas. Although there is limited coordination among the projects at the implementation stage, the diverse supplementation strategies being tested in streams like the Yakima, Grande Ronde/Imnaha, and Salmon rivers are being evaluated and will be compared among the projects with nearby natural populations. The results of these projects will help identify gaps in the research. Future investment should be in establishing robust experiments with un-supplemented reference streams and rigorous monitoring.

Future - The Council has been a leader, along with NMFS, in assembling and advocating principles of hatchery reform. Hatchery reform requirements are in all of NMFS' more recent biological opinions including the 2000 FCRPS opinion. The Council has been a participant in requiring Hatchery Genetic Management Plans (HGMPs) for all artificial propagation programs, an effort that is driving rapid reforms of hatchery operations. Local brood stocks and genetic management are being emphasized in new and reformed artificial propagation programs. Risks of genetic and ecological interactions are being considered in hatchery programs. Because of the Council and NMFS efforts, the ecological and genetic affects of artificial propagation are being addressed in research and in hatchery operations.

The concepts of hatchery realignment and reform only came into application for most ESUs about five years ago, and many of the actions that have been initiated have not yet generated enough adult returns to evaluate the impacts. Many of the experiments like Idaho Supplementation studies are long-term operations that will affect hatchery operations in the future e.g., the Nez Perce Tribal Hatchery are not even at full operation yet. Biological and physical facility constraints are factors, and it takes one or two generations to get an artificial propagation reform program operating, at least one or two more generations to evaluate and adapt, then one or two more generations to put improved operations into general use.

Management Needs: The hatchery system has become institutionalized within the Columbia Rive Basin and can be used to produce fish for harvest; maintain natural runs; and, address responsibilities under the ESA. This Research Plan provides a vehicle for addressing how hatchery operations can be integrated into the total production system and assist in the recovery efforts in the subbasin. The purpose and objectives of each hatchery should be established within the context of the subbasin where the hatchery operates, consider non-target species, and pay attention to the linkages between salmonids and their habitats, and the potential for metapopulation rebuilding. Research should be implemented to address the following management questions.

1. To what extent are hatchery production and supplementation programs detrimental to wild salmonid productivity and stock diversity? (Council Document SRG 93-2)

2. Have mitigation hatcheries replaced the fisheries (harvest) that were lost when natural production was lost?

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

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

5. How can we improve growth of post-smolt fish in captive broodstock programs?

6. Determine the most cost-effective method to reestablish spawning runs where wild fish populations have been extirpated and in newly restored or reconnected habitat.

Critical Uncertainties:

1. Is it possible to integrate natural and artificial production systems in the same basin to achieve sustainable long-term productivity? Some scientists and managers believe that it is likely that supplementation will produce an increased abundance of natural-origin fish, and that reformed hatchery practices can reduce the risks from supplementation to acceptable levels. Other scientists and managers not only doubt that the expected increases in abundance will be realized, but also believe that there is a high probability that supplementation will cause significant harm, reducing the productivity and abundance of the natural-origin component of the integrated population. In addition, supplementation (with unmarked hatchery fish) can introduce uncertainty through masking the numbers of natural-origin fish, making a determination of reproductive success difficult (for both natural-origin and hatchery-origin fish). The immediate net demographic benefit or harm to population abundance from supplementation depends on three things: intrinsic biological parameters of the stock in its environment, policy constraints, and management control variables. The integration of these factors, much less their measurement, has not been adequately considered in supplementation evaluations to date. For hatchery programs where the hatchery and natural population are integrated, the empirical basis is inadequate for determining the cost to the natural population. The impacts of these hatchery

programs on the extinction risk to, or recovery of, the remaining natural populations have not been determined empirically and these knowledge gaps need to be addressed.

2. Will natural stock production be self-sustaining if recovery hatcheries stopped? Reduced genetic fitness and habitat conditions will make it very difficult to have recovery hatcheries function as temporary supplementation, because natural production may decrease again after production is artificially increased. If this were the case, a continuous series of "temporary" supplementation efforts would be required.

3. Can hatchery programs provide harvest opportunities and restoring natural production and conserving wild populations at the same time? Hatcheries currently provide significant harvest opportunities. Yet there is uncertainty about whether risks to wild fish caused by these production hatcheries are being effectively and appropriately managed. There is also uncertainty about how hatcheries can and should be used in restoring natural production and conserving wild populations. There is general consensus among experts that individual hatchery programs likely cannot do both at once; therefore, it is necessary to identify very precise hatchery program objectives. Conservation programs should require exacting implementation designs focused on solving the specific conservation problem.

4. Is it possible to isolate and reduce interactions between production hatchery fish and naturally produced wild fish? What benefits and risks exist relative to the reconnection of resident fish isolated populations that have been artificially isolated?

5. What is the relationship between basin-wide hatchery production and the productivity (growth and recruitment to older age classes) of naturally produced salmon for a given level of ocean productivity? In the ocean the combined hatchery production of the entire Columbia River basin may decrease viability of wild production under less than optimal ocean conditions. Work in Alaska on pink salmon suggests that the ocean is limited and increased hatchery production just displaces wild production.

6. What are the ecological interactions of hatchery fishes? We need to understand the timing of "imprinting" of juveniles on their natal tributaries and how imprinting influences straying when adults return to spawn. Assured imprinting on a specific water source will reduce the potential for straying when fish are planted to establish a new wild spawning run.

7. Is the habitat capable of supporting salmonids at levels of survival that will bring about restoration? A major uncertainty associated with the use of supplementation is the condition of the habitat that will receive the hatchery-produced fish. The ecological conditions required to achieve benefits from supplementation have received little conceptual development or programmatic experimentation. The explicit connections between species survival, habitat, and water quality improvements are uncertain.

The Council's Research Recommendations: The genetic risks of supplementation as a means to increase natural spawners suggest that it would be prudent to continue to treat supplementation as experimental, that supplementation should only be deployed on a limited scale, and that better

and more extensive monitoring of such experiments should be required to generate an empirical record capable of evaluating those experiments.

Wild-Hatchery Fish Interactions

1.1 Determine the effects of wild-hatchery fish interactions and the potential for both beneficial and harmful impacts of hatchery management programs on wild stocks.

- What are the competitive impacts of hatchery and wild fish in a system? Is competition between hatchery and wild fish a source of mortality for wild stocks in the Columbia Basin e.g., are early releases on fall Chinook competing with upriver transitory fall Chinook?
- What are the predation impacts of hatchery on wild fish in a system e.g., are hatchery releases predators on wild salmon and steelhead stocks?
- Does maintaining wild characteristics help maintain meta-population diversity and increase long-term survival?
- Investigate whether the presence of hatchery spawners increases or decreases the productivity of natural salmon populations.
- What are the effects of supplementation on resident fish?

1.2 What are the effects of non-local origin strays and at what level does this straying become a problem for native stocks and what problems might they cause?

1.3 What is the scale of hatchery effects on natural populations compared to habitat loss, harvest, and changes in ocean productivity?

1.4 How can we better prevent and treat bacterial kidney disease (BKD) and predict the likelihood of vertical transmission of BKD from a specific female?

Genetics

1.5 What is the relative lifetime fitness of hatchery and natural salmon?

1.6 How can fish quality and health be improved to achieve appropriate survival and fitness of artificially produced salmon after release?

1.7 What are the ecological and genetic risks and benefits of various types of hatchery Programs?

1.8 How can hatcheries be managed so that genetic and life history characteristics of hatchery fish mimic those of natural fish?

- What broodstock collection protocols are most appropriate for supplementation programs?
- What spawning protocols are most appropriate for supplementation programs e.g., how should jacks be used in hatchery spawning to mimic their contributions in nature?
- How should we adjust the ratio of wild and hatchery fish and different age classes spawning in nature above a weir?
- What release strategies will best distribute hatchery adults on the spawning grounds?

1.9 What is the relative reproductive success of hatchery and natural adults in nature?

- How do culture practices influence reproductive success?
- What are the genetic effects of hatchery programs where a small number of parents produce a majority of the offspring?

1.10 Test the assumptions about survival differences between hatchery and wild fish; i.e., has interbreeding of hatchery and wild fish reduced the survival of wild spawning fish?

1.11 Conduct empirical research to identify links between fish genetics and life history patterns and unique adaptations and properties. (Montana)

1.12 Assess the feasibility of using additional genetic markers i.e., PINES, to determine the genetic integrity of individual fish. (Montana)

1.13 Identify all sources of native fish species that are genetically pure and free of all reportable pathogens. (Montana)

1.14 Determine the rate of domestication and re-naturalization of hatchery salmon populations. What are the long-term effects of domestication, what culture practices cause it and how can we minimize it?

1.15 Determine the exact timing of imprinting in juvenile resident salmonids, including native westslope cutthroat trout and bull trout. (Montana)

Techniques

1.16 What techniques best maintain wild characteristics in a hatchery population?

1.17 Develop hatchery-rearing methods to mimic the physiology, behavior, and life history patterns of natural populations to maintain life history types in hatchery, natural and composite hatchery/natural populations.

1.18 Evaluate methods to reestablish spawning runs where wild fish populations have been extirpated. (Montana)

1.19 Determine the long-term persistence of natural elemental signatures in fish scales. (Low priority)

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

1.21 Assess the effectiveness of batch marking of fish scales using applied concentrations of microelements as an alternative to thermal marking techniques in hatchery research. (Low priority)

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation

Who: NWPPC - APRE and ISAB findings, NOAA, USFWS

Hydrosystem

Overview: In regard to research that will improve mainstem habitat functions and values, the Council has adopted two important biological principles to guide decisions on fish passage and mainstem research:

1. Protect biodiversity, by designing passage solutions that benefit the range of species, stocks and life-history types in the river (which may require multiple passage solutions at a project); and,

2. Favor passage solutions that best fit natural behavior patterns and river processes.

In the past, the Council recommended that the hydrosystem operators ensure that their decision-making processes and criteria are consistent with these standards. This means developing research project ranking criteria and budget decision explanations that are responsive to protecting biodiversity and implementing passage solutions that favor natural behavior patterns and river processes.

The two principles are linked and provide a fundamental conceptual framework necessary for restoration of salmon and other anadromous fish stocks as described in Return to the River (Williams et al. 1996) and the ISAB's Review of the Corps of Engineers' Columbia River Juvenile Fish Mitigation Program (ISAB 1999). Technologies that most closely approximate the natural physical and biological conditions of migration would be most likely to accommodate diverse species/stocks. Multiple passage systems are needed to fully protect all anadromous stocks that pass through dams and impoundments. For example, surface orientated bypass systems take advantage of the natural tendency for yearling smolts to pass dams near the surface, while passage systems other than screens and turbines must be developed to pass juvenile lamprey and subyearling Chinook that pass dams lower in the water column.

Past - Various attributes of the hydrosystem such as slow moving reservoirs, mainstem habitat degradation, power peaking affects, elevated temperatures, turbines and screen bypass systems have contributed to fish mortality. The report, "Return to the River" extensively reviewed scientific literature and provided hypotheses regarding fish migration behavior e.g., "spiraling" Chinook migration, diel differences in behavior, effects of size and smoltification on travel time and depth of migration, and makes comparisons between free flowing rivers and impoundments, and their differing hydraulic characteristics. The report suggests that major alterations to the hydrosystem, such as drawdown, are necessary to achieve conditions suitable for juvenile salmonid migration as part of an adaptive management framework. Research under the Anadromous Fish Evaluation Program (AFEP) evaluates survival improvements dam by dam. Research should be conducted that does more than evaluate project survival, because project survival may not be a good indicator of life-cycle survival. In general, the focus of hydrosystem research should not be to evaluate incremental benefits or decreases to direct survival, which will be difficult to measure. Emphasis should be on full life-cycle effects of hydrosystem operations, including effects on resident fish.

Present: In April 2003, following a two-year public process, the Council adopted the Mainstem Amendments to its Columbia River Basin Fish and Wildlife Program that provide a broad range of recommended policies, operations and specific recommendations for future research. These amendments describe an experimental approach to many of the long-standing uncertainties regarding fish survival through different routes of passage and under different hydrosystem operational scenarios. To implement the amendments, a workplan was developed that sets forth 45 different tasks, many of which address specific research issues such as tests of dam operations. An important task for the Council is to establish priorities for this Mainstem Amendment work plan.

Council staff has conducted an informal internal prioritization, with the focus on summer spill and reservoir operations. Council staff will carry these recommendations forward into the formal process for establishing priorities in the Regional Forum. There are more tasks envisioned in the mainstem amendments than the Council's staff and budget resources can adequately cover. For this reason, staff will work with the Council to establish priorities for the tasks included in the work plan. This will help focus the Council's resources and advise other agencies on those tasks that offer the most immediate benefits and are likely to be the most important to achieving the Council's vision for the basin. (This section of the Research Plan is derived from the workplan for the Mainstem Amendments.)

Fish Passage - The best passage solutions are those that take into account and work with the behavior and ecology of the species and life history types, that mimic the natural situations and processes that emigrating salmonids encountered in their evolutionary history. Passage standards, objectives, designs and evaluations should focus on protecting the wide array of species and life history types in the river, not just a statistical measure of central tendency for the most abundant species. Passage standards, objectives, designs and evaluations, must be related to increases in adults back to the spawning grounds (smolt-to-adult survival rates), not just the incremental survival of juveniles or adults through the federal Columbia River hydropower system. River operations significantly different than the status quo should be tested to provide information to resolve key uncertainties about the hydrosystem impacts on anadromous fish.

The region is presently using surface passage systems for passing larger numbers of fish via spillway weirs. However, the present approach to evaluating RSWs should include spill up to the gas cap in order to determine when the maximum passage of fish via non-turbine routes occurs. In addition, these tests need to include a downstream survival component and survival to adult component in order to determine the impact of potentially reduced spill on predator abundance and success and any delayed mortality. It is important to fully test these passage systems and their impact on adult survival. Further tests should be conducted with the existing RSW's so that the region can be assured that future installations benefit fish survival.

Spill and Flow - A more comprehensive look at system survival needs to be undertaken to evaluate benefits of spill. Spill volumes have traditionally been closely tied to total discharge and so the benefits of spill on system survival have been difficult to assess because of the typically high correlation between spill proportion and total discharge. Given the number of RSW's being considered for installation this relationship could change and, a model of spill efficiency should change as well.

Research funded by the Corps is addressing the issue of bulk spill is proving in some cases to be superior to conventional spill across the spillway. However, approximately the same volume of spill is necessary to achieve survival and fish passage efficiency goals. It is not likely that reduction of current spill levels will result in the same or increased fish passage efficiency or survival levels, nor will tweaking spill levels provide a significant response to fish survival that can be separated from biological variability. Attempting to define "the proper" level of spill at each dam for each stock over each flow and river conditions will be cost prohibitive.
The Council has a high interest in assessing the benefits of various levels of spill but the feasibility of conducting such studies is uncertain. The experimental design requirements that would be required to detect and isolate the incremental effects of varying spill levels would be challenging. Spillway passage and project operations should be optimized to maximize survival.

Management Needs: From a policy perspective, the Council has an interest in emphasizing research in the areas of mainstem operations including spill, flow augmentation and fish transportation.

1. Evaluate the ecological effects of hydro operations on downstream fish and wildlife populations and habitat.

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

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

4. Implement and test new spill technologies such as removable spillway weirs and fish guidance systems, prior to widespread installation.

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

6. Evaluate the benefits of incremental flow augmentation and determine the mechanisms for temperature/turbidity relationships on the Columbia and Snake rivers.

7. How can hydro projects operate to provide improved temperature regimes?

8. Implement and test new hydro-operations to improve and increase water quality e.g., DO, temperature, TDG, toxics, and sedimentation, and fish survival.

9. How can we manage the system to optimize the combined effect of multiple management goals, such as flow regimes, spill, temperature, TDG, fish passage, etc.?

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

Critical Uncertainties:

1. The cumulative indirect effects of passing multiple dams during migration are uncertain.

2. Significant uncertainty persists regarding the behavior, life history, feeding, and nearshore survival characteristics of the juveniles the program seeks to protect; i.e., fall Chinook reservoir type optimal entry into saltwater.

3. What is the efficacy of the current operational measures designed to protect outmigrating juvenile fall Chinook? Recent studies on outmigrating juvenile fall Chinook indicate that they have a more complex migratory life history than previously thought. These findings may call into question, the estimated juvenile survival through the hydrosystem and the current application of transportation, spill and flow augmentation to protect fall Chinook (see ISAB Findings from the Reservoir Operations / Flow Survival Symposium 2004-2).

4. The relationship between levels of flow and juvenile and adult salmon survival through the Columbia hydrosystem needs greater clarification. The present flow management strategy does not take into account the complex migratory behaviors of juvenile salmonids. For example, there is considerable uncertainty about the effects that changes in river flows and water temperatures designed to aid yearling migrants has had on subyearlings.

5. What is the relationship between inriver gas supersaturation levels and fish inriver survival? The supersaturation-exposure histories of inriver fish are not well understood, and these variable exposures are not easily related to laboratory dose-response experiments. Furthermore, injured fish can be lost through predation, disease, or other ecological factors that are not well quantified at the present time.

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

7. The biological effects of flow augmentation from Libby and Hungry Horse on salmon survival in the Lower Columbia River. Design and implement new studies in the lower river to better understand the movement and survival of fall Chinook. Determine the best methods to separate the effects of dam operation from unrelated factors that affect recruitment and survival. (Montana)

8. Understanding the optimal temperature regimes in impounded mainstem and tributaries to support salmonid survival, and identifying hydro operations that can help meet these optimal temperature regimes. Current criteria that are based on the 7-day average of daily maximum temperatures over the water body, but other measures of spatial and temporal variability might

also be *needed* for salmonid protection, such as the average daily temperature, minimum daily temperature, and the presence of cold water refugia.

The Council's Research Recommendations:

	Fish Passage
2.1	Determine the life history patterns of fall Chinook outmigrants.
2.2	Examine the efficacy of current operational measures designed to increase survival of juvenile fal1 Chinook.
2.3	Conduct research necessary to design, test, and implement new surface passage systems, e.g. flow velocity enhancement using directed turbulent currents, removable spillway weirs.
2.4	Continue to develop rigorous evaluations of spillway passage at each mainstem project. Determine an optimal passage strategy at each dam and for each passage route that maximizes improvements in survival.
2.5	Evaluate new fish guidance technology to concentrate fish at fish passage structures.
2.6	Conduct the necessary feasibility studies to restore anadromous and resident fish to blocked areas, not including areas blocked by natural barriers.
	Spill and Flow
2.7	Identify ocean versus reservoir type life history traits for fall Chinook and the effect of these different migration strategies on juvenile hydrosystem survival.
2.8	Re-evaluate the use of flow augmentation to speed migration in light of the reservoir life history pattern.
2.9	Determine how transportation affects the proportion of smolts utilizing the life history strategy.
2.10	Measure the physical features of flow important to fish migration and survival e.g., water velocity or within-day variations due to load following (power peaking).
2.11	Design and implement a comprehensive, system-wide research program that will integrate biological and physical responses of various flow operational strategies at each dam in the Columbia Basin Power and Flood Control System with overall system survival and critical habitat evaluations. (Montana)
2.12	Implement summer spill tests as soon as possible to examine the benefits of the current summer spill program for outmigrating juvenile fall Chinook.
2.13	Determine the impacts of water releases and reservoir levels on resident fish and their prey species. (CBFWA)
2.14	Determine the best pattern of lake level changes for Lake Pend Oreille and the Pend Oreille River above Albeni Falls Dam to improve shoreline spawning habitat for kokanee, over-winter habitat for warm water fish, enhance near-shore productivity, and prevent shoreline erosion. (CBFWA)
2.15	Determine the effects of altered temperatures on salmon and their relationship to flow. • Determine how to provide storage reservoirs with selective withdrawal systems to create a more normal annual temperature cycle in the rivers. • Determine the best selective withdrawal systems from storage reservoirs to more normalize or mitigate the annual temperature cycle in the river.

	• Determine whether free-flowing reaches downstream of hydroelectric dams can be regulated to achieve normative flow and temperature regimes thereby allowing the river to naturally restore instream and floodplain habitats and food webs.
2.16	Evaluate biological effects of the NWPPC's Mainstem Amendments on the fisheries upstream and downstream of Hungry Horse and Libby Dams. Implement experimental operations at Libby and Hungry Horse Dams that limit summer draft to 10 feet from full pool by the end of September. (Montana)
2.17	The evaluation of the limited draft at Libby and Hungry Horse on flow augmentation should be expanded and also include additional drafting of these reservoirs. The analysis should address a range of summer flows, and varying operations of Grand Coulee (1278 or 1280 draft), Albeni Falls (2051 of 2055 draft) and Canadian Projects.
2.18	Evaluate the benefits for listed bull trout and Kootenai white sturgeon of the Council's proposed reservoir drafting strategy and summer flow augmentation. (Montana)
2.19	Document the amount and timing of flows required to stabilize and improve Kootenai white sturgeon and burbot populations in the Kootenai River.
2.20	Develop instream flow models to assess biological and physical impacts of dam operations (river and reservoir) on native fish survival (and growth) and habitat availability in the Flathead and Kootenai Rivers. Conduct empirical studies to assess accuracy of instream flow models for the Kootenai and Flathead Rivers. (Montana)
2.21	Implement the 10-year study to assess the feasibility of prescribed ramping rates called for by the USFWS 2000 BiOp in the Flathead and Kootenai River systems. (Montana)
2.22	Continue to evaluate turbine passage to determine the optimum fish survival through turbines. Continue the research and design work on improved turbines and the relationship between survivals and overall turbine operating efficiencies.
2.23	Modify turbine designs to improve juvenile salmon passage survival. Evaluate alternative designs and implement as soon as possible in those dams where they would provide the greatest biological benefits.
	Transportation
2.24	Continue studies to determine the optimal transport strategy and determine the best estuary release dates.
2.25	Continue to evaluate survival benefits of transport from McNary Dam to determine whether the benefits are sufficiently greater, at least under certain circumstances, than inriver passage to justify continuing (or increasing) the transportation.
2.26	Continue the transportation study targeting Snake River fall Chinook. Evaluate relative success of transporting various groups of fall Chinook throughout the Snake River through the current transportation study.

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:

Who: NWPCC, Bonneville Power Administration, U.S. Army Corps of Engineers

Anadromous Fish Evaluation Program

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

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

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

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

The AFEP lacks, but would benefit from, a strategic, multi-year Research Plan or framework. Strategic multi-year Research Plans with contingencies and alternative tests built in would make the program stronger by reducing time and resources spent annually. The Corps should conduct strategic planning to identify where a more mechanism-oriented strategy e.g., behavioral or mortality mechanisms, could yield benefits in research productivity, efficiency and economy of time and funds and thus faster implementation of fish-protective features.

While the Corps of Engineers provides funding for considerable research, their projects are not adequately coordinated with other research efforts and the research is often directed at less relevant issues with regard to fish recovery objectives.

There is no independent-peer review process to improve proposals funded by the Corps of Engineers. In comparison, the Council's recommended research undergoes more scrutiny with an independent peer review. Further, stocks such as Pacific lamprey are given very little priority under the Corps' program. The Council should work with co-managers to assure that the Corps' research program undergoes proper peer review and is integrated with the Council research on both a programmatic and a project by project.

Habitat

Tributary and Mainstem Habitat

Overview: Sustained fish and wildlife productivity requires a network of complex and interconnected habitats, which are created, altered, and maintained by natural physical processes. Fish and wildlife habitat has been severely degraded in the Columbia River Basin by dams and diversions, sedimentation from forestry and agriculture activities, and introductions of nonnative species. Fish and wildlife populations have been substantially depleted by habitat loss, fragmentation, and degradation. Restoration efforts must focus on restoring habitats and habitat connectivity, and developing ecosystem conditions and functions that will allow for expanding and maintaining diversity within, and among, species in order to sustain a system of robust populations in the face of environmental variation.

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

Yet very little is known about how habitat improvements will affect target populations. Quantifying the results of restoration activities by having a monitoring program that compares the effect of the restoration will be fundamental to success. For many restoration actions, the relative recovery time frames are not well quantified. Thus, it will be important to assess not only the projected benefits of a restorative action, but the length of time needed to achieve those benefits and the rate of habitat improvement over time.

Research should be conducted to assess the habitat potential of a particular site; i.e., how production changes as habitat changes. Currently, such information is lacking for most habitats, though elaborate systems exist to approximate such information e.g., EDT. It is important to determine what sort of improvements we would expect in habitat and target populations as a result of specific restoration activities and then monitor the restoration activity to determine whether the predicted result was obtained. The knowledge from the monitoring of these restoration successes or failures need to be incorporated into future restoration designs.

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

Habitat Refugia - Habitat refugia have been identified as an essential part of the ecosystem for anadromous and resident fish. The protection and restoration of important aquatic habitats as refugia for the long-term conservation of anadromous and resident populations within the basin will require research to identify such areas.

For example, the 2000 FCRPS Biological Opinion called for continued research into the distribution of bull trout within the mainstem Columbia and Snake rivers. Bull trout migrate seasonally from some local populations to the mainstem Columbia and/or Snake Rivers, using mainstem habitats during a portion of their life history. Research is needed on the movement, seasonality, and importance of use of different habitat types in the Columbia and Snake Rivers by adult and subadult bull trout. For fluvial bull trout using mainstem habitats, the timing of use (arrival and departure), the habitat conditions in the mainstem associated with these movements, the manner in which fish use the mainstem, the frequency with which fish enter or leave the mainstem, and the fidelity that fish have to a particular tributary all need to be determined.

Bull trout, ranging in size from about 150-250 mm, often adopt migratory lifestyles and use a surprising array of habitats. The typical model for bull trout; migrating to larger main-stem, laucustrine, or marine habitats, does not seem to apply for these small fish. Although small bull trout utilize these habitats, they also move up into very small tributaries on a seasonal basis. Thus, a much larger portion of the stream network may be more important for bull trout than previously understood. (This same issue has been highlighted by recent work on seasonal habitat use by migratory coastal cutthroat trout. The logistics of working on any salmonids of this size are considerably more difficult, since telemetry is more difficult, and monitoring fish movements with PIT tags or other marking methods is extremely labor intensive.)

Most of the focus on bull trout habitat requirements has been on spawning and rearing areas. However bull trout do use a large portion of the basin. Over 60 telemetry studies involving more than 3,000 fish have been conducted throughout the species range. (Data from bull trout telemetry synthesis project can be accessed from this website www.northwestbulltrout.com.) Although the vast majority of this data has not been published, Forest Service scientists are

currently working to develop approaches to analyzing patterns of habitat use, and have drafted a list of key site and landscape variables.

For many years, Forest Service research scientists have advocated a "patch-based" view of bull trout habitat refugia on the landscape. (Refugia are relatively pristine areas containing native species assemblages and managed as wilderness or roadless areas that provide a living laboratory for future research actions.) However, there is still only one example where this approach has been implemented e.g. the Boise River basin. Several studies in the Boise basin have demonstrated the value of this approach for understanding long-term persistence, monitoring, and interpretation of genetic population structuring. The Western Division AFS Bull Trout Sampling Protocol suggests that patches could also serve as the building blocks of a monitoring strategy, habitat protection and restoration programs, and the planning for bull trout reintroductions currently underway in the Willamette, McKenzie, and Clackamas River basins.

Physical Processes: In order to identify and conserve aquatic diversity and integrity, it will be necessary to define key ecological processes and key ecological functions of species from both a current and historical perspective. One of the most important concepts emerging from landscape ecology and ecosystem theory acknowledges the dynamic and complex nature of most natural systems and their linkages across scales of space and time. The dynamics of physical process in aquatic ecosystems can be manifested in the form of major events that substantially affect physical environments and associated species. Often, such events are described as "disturbances." Whereas some forms of "disturbance" may be viewed as potential threats to species and ecosystem function e.g., forest roads and associated effects, other forms may indeed be essential to natural ecosystem function. For example, large disturbances such as fire and associated hydrologic events have been obvious forces structuring these systems in recent time, but also in deeper geomorphic and evolutionary history. Disturbances will undoubtedly continue to be important in the future and may even become more pronounced. Predicting the effects of different natural and human related disturbances to freshwater ecosystems and ensuring the resilience of these systems to those disturbances represent central problems in natural resource management. Management that ignores the fundamental physical and ecological processes structuring and maintaining natural systems, and their inherent variability, will likely fail.

Chemical Processes: Scientific understanding of the role of nutrients in the growth of juvenile salmon in freshwater and estuarine conditions is incomplete. Fewer adult salmon returning to spawn in many streams, resulting in decreased transport of nutrients such as nitrogen and phosphorus. Research has shown the large reductions in adult returns to the Columbia River system have reduced fluxes of carbon, nitrogen and phosphorus. The upstream transport of nitrogen by salmon has been demonstrated by the differences in the isotopic composition of nitrogen between reaches with spawning salmon and without.

However, the conclusions derived from these findings and the practices adopted, however, are not well supported. The lack of understanding of how the nutrients and calories flow through the food web in freshwater to juvenile salmon (and how it varies between the different species and lifestyles of salmon and different stream systems) has led to the adoption of a simplistic model. Specifically, if there are estimated to be fewer spawning salmon than before we have records, then add carcasses, or equivalent nutrients to replace the presumably missing carcasses. Yet in

many instances, anthropogenic impacts have resulted in significant increases in the flux of nutrients into streams. It has also resulted in a loss of rearing habitat for salmon that is fewer juvenile can be supported and the system may need fewer returning salmon to support the maximum sustainable salmon population. The ecology of naturally functioning streams which support healthy salmon runs need to be better understood, otherwise it will be difficult to determine whether a stream has been culturally oligotrophicated; i.e., the loss of nutrient inputs due to the reduction in spawning salmon, or whether other cultural activities have replaced the nutrients once provided by spawning salmon. Recent studies indicate that these nutrients have also affected the distribution and abundance of other plant an animal species in adjacent upland communities.

Management Needs: From a policy perspective, the Council has an interest in emphasizing research in the areas of rearing and spawning habitat, particularly quantification of benefits from riparian protection, improved screening and increased seasonal water flows.

1. What are the most effective Best Management Practices for protecting habitat?

2. Identify and protect habitat that supports existing populations that are healthy and productive and seek to increase the extent, diversity, complexity and productivity of habitat by protecting, enhancing and/or connecting spawning, rearing and resting areas.

3. Identify ecosystem conditions and functions that expand or maintain diversity within and among species and the processes that lead to the support of self-sustaining populations at a variety of scales e.g., subwatershed to basin.

4. Quantify the benefits of on-the-ground habitat restoration and protection measures.

5. Identify the impacts of hydrosystem induced lake level changes on shoreline spawning habitat on natural lakes that have been impounded. (CBFWA)

6. Identify the effects of nutrient imbalances and their relationships to changes in the key ecological functions of the historical suite of native species.
    - Determine an independent measure of the appropriate nutrient level in streams e.g., criteria based upon the abundance or composition of communities of benthic macro-invertebrates or epilthic communities.
    - Determine the value of salmon pellets/carcasses, as well as inorganic nutrients, to increase habitat productivity.

Critical Uncertainties: The critical ecosystem features for the full life cycle of salmonid species and stocks must be defined (CENR, 2000). What pattern and amount of habitat protection is needed to insure long-term survival of fish and wildlife populations in the face of variable environmental regimes?

The relationship between habitat and fish and wildlife productivity is dynamic. Understanding these relationships is critical to conserving and restoring habitat that will meet population-based

restoration, recovery, and conservation. Therefore, a comprehensive life-cycle approach that addresses both natural variability in environmental conditions and human impacts on physical, chemical, and biological processes affecting fish and wildlife populations must be defined. Although "best management practices" (BMPs) may reduce impacts to habitat compared to unregulated land use, uncertainty about effectiveness of present BMPs must be resolved by scientific evaluation at both site-specific and watershed scales.

It is important to re-establish the seasonality of flow and temperature and to stabilize base flow and temperature fluctuations. The exact magnitude and timing of restored flows and temperature regimes is uncertain and should be empirically determined for specific free-flowing segments, via a broadly multidisciplinary approach. (CBFWA)

There is a need for scientific research to determine how to restore the ecological functions and develop techniques for reestablishing healthy watersheds. It is also uncertain how the operation and configuration of the hydrosystem impact mainstem habitat conditions.

The Council's Research Recommendations:

Biological Processes

3.1 Test and compare the effectiveness of "Best Management Practices" in use by different agencies for new timber harvest prescriptions, sustainable agriculture practices, and other land use practices for upland and riparian areas. Determine the most effective techniques for:

- improving connectivity of streams with the floodplain;
- increasing inter-gravel survival of incubating fry;
- increasing food supplies in the mainstem during outmigration; and,
- reducing sedimentation due to land clearing practices.

3.2 Determine how changes in terrestrial wildlife communities can affect salmonid habitat and productivity e.g., loss of key ecological functions.

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

3.4 Identify critical habitat conditions for bull trout, westslope cutthroat trout, burbot, redband trout and Kootenai white sturgeon, and assess potential to improve existing habitat conditions where deemed necessary. (Montana)

- Identify habitat elements necessary for bull trout and develop an inventory of streams that provide the cold-water habitat conditions necessary for bull trout, westslope cutthroat trout, native redband trout, and burbot, such as coldwater refugia and migration corridors in larger rivers. (WA DOE)
- Develop patch-based models of suitable habitat with bull trout on the west side of the Cascades and Columbia Gorge and identify key site and landscape characteristics that define habitat capable of supporting persistent populations.
- Determine the importance mainstem habitat for recovery of bull trout and other native salmonids throughout the Columbia River system. (Montana)
- Map the distribution of potentially suitable habitat for large migratory bull trout throughout the species range.

3.5 Continue to evaluate the amount, location, and quality of spawning habitat for resident and anadromous fish e.g., fall Chinook and Chum core populations in the lower and mid-Columbia area, and fall Chinook in the lower Snake area. Conduct new evaluations for steelhead, white sturgeon, mountain whitefish, and Pacific lamprey.

3.6 Integrate analysis of upland and aquatic habitat characteristics and spawner surveys with models to assess trends in population dynamics.

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

3.8 Conduct an integrated assessment of the role of primary and secondary production in regards to action options for restoration of riverine food chains such as induced flooding, hydro operations, and riparian habitat restoration to promote ecologically based food webs. For example:

- Determine the value of macrophytes for producing food for mid-Columbia river fish.
- Compare and contrast native versus invasive macrophytes for habitat and food production.
- Determine insect colonization and growth during flooding and spatial analyses of floodplains.
- Determine the quantity of salmonid food potentially produced by flooded riparian lands in the lower Columbia-Snake basins and lost by river regulation, and relate quantitatively to the food requirements of migrating juvenile salmonids.
- Determine the stability and productivity of food production in nearshore rearing areas.

3.9 Determine the availability of food, food habits, and the nutritional state of:

- Juvenile salmonids during transportation from upper river dams to below Bonneville Dam;
- Migrating Snake River salmonids in relation to that of mid-Columbia stocks; and,
- Juvenile fall Chinook in the Hanford Reach.

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

3.11 Determine how to stabilize and improve burbot populations.

3.12 Determine survival for Hanford Reach subyearling fall Chinook through McNary Pool and downstream to below Bonneville Dam.

Physical Processes

3.13 Conduct the necessary feasibility studies to restore, where feasible, anadromous fish to blocked areas and resident fish to blocked habitat.

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

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

3.16 Identify the role of habitat condition on the invasion of nonnative fish species; i.e., can habitat restoration activities be designed to reduce the likelihood that nonnative species will invade and replace native species? (Montana)

3.17 Assess biological responses associated with habitat restoration and fish passage

improvement projects. (Montana)

3.18 Assess the potential to increase the abundance of large woody debris in the Flathead River downstream of Hungry Horse Dam. (Montana)

3.19 Determine the impacts of water releases and reservoir levels on resident fish and their prey species. (CBFWA)

3.20 Determine the best pattern of lake level changes for Lake Pend Oreille and the Pend Oreille River above Albeni Falls Dam to improve shoreline spawning habitat for kokanee, over-winter habitat for warm water fish, enhance near-shore productivity, and prevent shoreline erosion. (CBFWA)

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

3.22 Determine the best selective withdrawal systems from storage reservoirs to more normalize or mitigate the annual temperature cycle in the river.

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

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

3.25 Determine the geographic distribution of suitable or potentially suitable fall Chinook spawning habitat in the tailraces and upper pool areas of the four lower Snake River projects and the mainstem Columbia River projects downstream from Grand Coulee Dam.

3.26 Conduct a comparison of the physical attributes of alluvial mainstem rearing habitats and floodplain areas created under the various drawdown scenarios, with the physical attributes of the adjacent downstream reservoir areas. Determine distribution, abundance, food habits, and growth of rearing subyearling fall Chinook for both types of areas.

3.27 Evaluate the relationship between physical conditions associated with both steady state and fluctuating flow scenarios and spawning activity and success by white sturgeon.

3.28 Develop spring flow recommendations for white sturgeon spawning habitat targets in all mainstem spawning areas in conjunction with development of flow targets for salmonid downstream migrants.

3.29 Evaluate passage conditions for white sturgeon at mainstem projects and develop recommendations for modifications in conjunction with similar work for Pacific lamprey.

3.30 Determine whether spawning success or survival of juveniles is the limiting factor on recruitment and production in each of the mainstem spawning areas.

3.31 Investigate the effect of conditions recommended for mainstem fall Chinook production on spawning and rearing conditions for white sturgeon.

3.32 Determine how temperatures in tributaries, and other coldwater refugia, such as ground water upwelling and hyporheic exchange, are part of the environmental change that has fragmented salmonid habitat, and support existing programs to improve tributary temperatures for salmonids e.g., TMDLs and watershed planning. (WA. DOE)

Chemical Process

3.33 Determine the impacts of declining wild salmonid populations on ecosystem processes, such as the transport of marine derived nutrients from ocean to upland settings, and consequent changes in species and key ecological functions. Evaluate nutrient cycling, carcass increases, and productivity of macro-invertebrates.

3.34 Determine how water quality (DO, toxics, pH) and flow in tributaries are part of the environmental change that has fragmented salmonid habitat, and develop programs to improve tributary water quality and flow for salmonids. (Oregon DEQ)

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:

NOAA Fisheries' 2000 Biological Opinion calls on the federal Action Agencies, in conjunction with the Environmental Protection Agency and the U.S. Geological Survey, to develop a program to 1) identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships and identify research needs; 2) develop improvement plans for all mainstem reaches; and 3) initiate improvements in three mainstem reaches. The USFWS 2000 Biological Opinion also contains similar measures for Kootenai white sturgeon and bull trout. (CBFWA)

Subbasin plans provide a vehicle for coordinating activity in support of the protection and restoration of habitat. Additional research will be necessary to develop means for quantifying the benefits from a wide variety of coordinated actions. For example, it will be important to measure the benefits from riparian and upland protection, improved screening at water diversions, and increased seasonal flows. While we can assume such actions will be good for fish, there is little information about the magnitude of these benefits or how they may vary under different conditions. One potential approach is to compare treatments to a group of streams of identical stream order, habitat type and gradient over time. Post-treatment samples can be compared collectively to determine if the treatment group responds differently than the natural variation in the controls. Another approach is to compare the relative contribution of juvenile recruits from various streams to the parent population over time. To do this, we must be able to determine the natal stream of origin of individual fish after they emigrate from their natal stream. (Montana)

Tributary habitat is essential for spawning and rearing of many resident fish species. It is often more cost effective to reconnect blocked habitat, than to repair damaged habitat. Habitat reconstruction, however, may be the only option available to replace habitat that was lost due to inundation when storage projects were constructed. A mixture of these strategies should be evaluated to focus mitigation actions on the most effective techniques to restore species of special concern. Habitat projects that benefit terrestrial and aquatic communities should be the highest priority. (Montana)

Estuary

Overview: The Columbia River estuary is an important ecological feature of the Columbia River Basin, constituting the physical and biological interface for salmon and trout as they transition between their freshwater and ocean life stages. Juvenile anadromous fish utilize various areas in the estuary to rear and undergo adaptation to marine conditions. Rearing locations, seasonal timing, residence timing, and migration pathways differ between species and stocks. The Columbia River estuary also provides important rearing habitat for other animal species of marine origin, and year-round habitat for species that have evolved to live solely within an estuarine environment.

The Columbia River estuary has undergone tremendous changes as a result of settlement and development, and these changes have affected its physical character and biological resources. Physical characteristics such as depth, velocity, salinity, temperature, and turbidity vary dynamically within the Columbia River estuary, presenting a highly variable environment. The environmental changes that have occurred have substantially affected habitat availability, habitat quality, species composition, and other biological attributes of the estuarine ecosystem. The complexity of the physical and biological processes and interactions within the Columbia River estuary system contribute to the challenges and opportunities faced by aquatic organisms. While less is known about the potential for improvement in the estuary compared to other parts of the Columbia River Basin, there are indications that substantial improvements are possible, and that these improvements may benefit anadromous fish populations (Kareiva et al. 2000). The estuary has been impacted by local habitat and upriver management actions. Although all of the investment and effort in the Fish and Wildlife Program flow through this unique environment, the interaction of changes in the estuary with restoration projects has not been evaluated. Therefore a precautionary approach should be taken, given the current state of most salmonid populations in the Basin, the magnitude of change in the estuary, and the lack of prior research.

Characterization of the estuary's physical and biological attributes that support salmon is underway, but is in its infancy. The draft NMFS report, *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon*, assessed the potential impact of flow regulation on juvenile salmon utilization of the estuary. The report found that hydrologic and climate factors likely have consequences for the estuarine physical environment. However with the existing data it is not possible to separate these effects from compounding factors or to rank these factors' effects on salmon. Nevertheless, it is clear that reductions in tidal wetland habitats, such as marshes and swamps, have occurred that affect the estuary's capacity to support juvenile salmon and that have reduced habitat complexity. The Bonneville sponsored report, *An Ecosystem-Based Approach To Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary*, provided a scientific basis and implementation guidelines for a habitat restoration program designed to improve ecosystem functions and enhance juvenile salmonid survival in the Columbia River estuary.

The ISAB recommended an aggressive experimental program to reduce the likelihood of prolonged uncertainty about the impact of estuarine conditions. The ISAB also recommended incorporating monitoring of the physical environment, such as that currently under way by the Oregon Graduate Institute, with evaluation of large-scale manipulations of estuarine habitats.

The intent of these restoration treatments would be to study changes presumed to have had negative impacts and to conduct these at a scale that can be measured within the natural environment.

Management Questions: From a policy perspective, the Council has an interest in emphasizing research in the areas of estuary and near shore ocean habitats.

1. What actions in the estuary are most beneficial in affecting abundance, productivity, spatial structure, and diversity (VSP parameters) that enhance persistence of salmon populations.

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

3. What are the highest priority habitat types for restoration?

4. What are the highest priority ecological functions for restoration?

5. What are the cumulative effects of multiple restoration projects?

6. What is the connection between species survivability, habitat, and water quality?

7. What is the relative importance of estuary and tributary habitat restoration actions?

Critical Uncertainties:

1. It is uncertain which estuarine habitat types should have the highest priority for restoration.

2. The effectiveness of estuarine habitat restoration on Columbia Basin salmon and trout populations is uncertain.

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

4. The ecological significance of the estuary plume is uncertain.

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

6. The Lower Columbia Channel Deepening project is a Critical Uncertainty that applies to habitat, recovery planning, monitoring and evaluation, harvest management, natural variation and ocean productivity, and toxics research recommendation topics.

Research Recommendations: In 2003 the Lower Columbia River and Estuary Partnership (LCREP) and the Army Corps of Engineers sponsored a Lower Columbia River and Estuary Research Needs Identification Workshop. The following list of research recommendations is largely drawn from the proceedings of that workshop and the Bonneville sponsored *Plan for Research, Monitoring, and Evaluation of Salmon in the Columbia River Estuary* (Johnson et al. 2004).

Biological

4.1 Determine the linkages between salmonid life history diversity, population fitness, and survival in the estuary and estuarine habitat conditions.

- Conduct research on food web dynamics and the key ecological functions of the estuary.
- Conduct research to understand juvenile and adult migration patterns and residence times.
- Determine the downstream migration timing of juveniles to optimize food availability in the estuary.

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

4.3 Conduct research on the effects of invasive species and the feasibility to eradicate or control them and reinstitute research and monitoring of invasive species in the estuary.

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

- Determine the optimal timing to release salmon juveniles in the estuary to avoid avian predators.

4.5 Conduct research on the linkages between physical and biological processes, such as: evaluate flow effects, river operations, and estuary-area habitat changes on the relationship between estuary and near-shore plume characteristics and the productivity.

Physical

4.6 Develop a metric of habitat connectivity in order to track changes in reconnection restoration efforts. Evaluate removal of dikes in the lower river and upper estuary to restore connections between peripheral floodplains and the river or fluvial zone of the estuary.

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

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

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

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

Chemical

4.11 Develop a comprehensive, long-term water quality-monitoring program for the estuary that includes pollutant fate and transport.

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

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

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation

Who: Lower Columbia River and Estuary Partnership, Army Corps of Engineers, Bonneville Power Administration, NOAA, U.S. Fish and Wildlife Service, Oregon State University.

Natural Variation and Ocean Productivity

Overview: Global and regional-scale processes in the ocean and atmosphere can regulate the productivity of local marine, estuarine, and freshwater habitats for anadromous species such as lamprey and cutthroat trout. Although managers cannot control these processes, natural variability must be understood to correctly interpret the response of fish to management actions in the Columbia Basin. For example, salmon abundances in the California Current region (off Washington, Oregon, and California) and in the Central North Pacific Ocean domain (off British Columbia and Alaska) respond in opposite ways to shifts in climatic regime. During periods of a strong Aleutian Low, zooplankton and salmon production generally increase in the Central North Pacific and decrease in the California Current, suggesting geographically distinct mechanisms of aquatic production. Climatic shifts characteristic of the strong Aleutian Low regime occurred twice this century: one from about 1925 to 1946 and another in 1976/77 to the present. Both periods were marked by precipitous declines in the coho salmon fishery off Oregon. Opposing cycles of salmon abundance between the Central North Pacific and the California Current regions underscore the importance of stock-specific regulation of ocean fisheries. Even during periods of high marine survival off Oregon, harvest limits must ensure that Columbia Basin stocks are not overexploited by northern fisheries trying to compensate for coincidental decreases in the production of stocks from Alaska and British Columbia.

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

Decadal cycles of ocean productivity have the potential to mask changes in the survival of salmon during freshwater phases of their life cycle, leading to erroneous interpretation of the

performance of restoration efforts and increased losses of some stocks. The dynamics of salmon metapopulations will change under different climatic regimes if, for example, the dispersal of core populations or the rate of extinction of satellite populations is a function of fish density.

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

Management Needs:

1. Determine the effects of ocean conditions on anadromous fish populations.

2. Evaluate or adjust inland management actions in response to ocean conditions.

3. Determine if hatchery production should be scaled back during periods of low ocean productivity in order to minimize competition in the estuary or marine environments.

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

Critical Uncertainties:

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

2. Information on stock-specific distributions of Columbia Basin wild salmon in the ocean and the migratory patterns of hatchery versus wild salmon is limited.

3. There is increasing evidence worldwide that ocean fisheries on groundfish and coastal pelagic species such as halibut, Pacific Whiting, squid, sardines, anchovies, etc., may have significant impacts on the food web important for salmonids.

4. Harvest management programs based on stock recruitment relationships and monitoring of individual species do not provide adequate indicators of the effects of harvest activities on ocean food webs.

The Council's Research Recommendations:

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

5.2 Do hatchery practices affect the migratory patterns and potential marine survival of salmon?

5.3 Determine if components of estuarine and marine mortality relate to predation versus competition, and whether the large-scale oceanographic and climatological shifts impact these relationships. (Confederated Tribes of the Umatilla)

5.4 Determine the relative effects of the ocean on different fish stocks compared to the effects of inland actions.

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

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation

Who: NOAA, Oregon State University, University of Washington

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

Harvest

Overview: Harvest management has changed substantially since listing of anadromous salmonids and bull trout, with particularly large changes in recreational fisheries management since the listing of several steelhead ESUs between 1997 and 1999. Harvest is managed under biological opinions that ensure fisheries do not pose jeopardy to listed fish species and that harvest is not an impediment to recovery as ocean harvest of the most endangered stocks is low to non-existent.

Harvest, hydrosystem, habitat, and hatchery management have all failed to consider the relation of abundance to other components of the ecosystem, which are connected by the life cycle of the species. Most current harvest management targets fish from mitigation hatcheries. Productivity to support harvest has been largely divorced from production in natural habitat. Harvest regulation is a sufficient means of protecting and increasing production only in the presence of reasonably pristine habitat. Estimates of production from habitats that are constantly declining in productivity will always be too high. Under an ecosystem approach for management and recovery planning (e.g., the All H paper), all mortality sectors must be managed to reduce mortality. Although the Council has no statutory role in developing harvest levels, it can facilitate efforts to monitor and evaluate existing terminal and selective fisheries.

The ISAB Harvest Management Review addressed the question, what constitutes a sound scientific basis for the management of Pacific salmonids in the Columbia River Basin? The ISAB reviewed the scientific issues associated with harvest management, including the

establishment of biological management goals, the information needs for monitoring and evaluation, and relationship to recovery planning. The ISAB evaluated: the ability to manage for smaller population groups given current methodologies; the concept of over-spawning; the role of salmon in the ecosystem; the treatment of uncertainty in stock assessments and management evaluation; and, the assessment of harvest within a life cycle and recovery context.

The ISAB review also examined the effects of climate variability on the marine environment and the interplay of harvest, hatchery production, and varying ocean regimes. If marine survival continues to improve, resulting in large returns of some stocks, then harvest will become an increasingly important scientific issue.

Management Needs: From a policy perspective, the Council has an interest in emphasizing research in the areas of evaluation of new approaches to harvest, such as selective harvest technology.

1. Can harvest be managed in mixed-stock areas like the ocean and mainstem Columbia by ESU or even individual populations?

2. What the level of escapement at the watershed scale necessary to ensure that over-harvest of anadromous and resident is not taking place?

3. Identify and implement the equipment and marking techniques necessary to establish selective harvest techniques e.g., adipose fin clips, PIT-tagging.

Critical Uncertainties:

1. Directed and incidental harvest of Columbia River Basin salmon has occurred in the absence of definitive knowledge of harvest impacts on the abundances and viabilities of the majority of the individual native spawning populations. Specific information is only available for a limited populations and general knowledge is often applied to aggregates of wild populations. (USWFS)

2. Uncertainties exist regarding stock-composition and stock-specific abundance, escapement, catch, and age distribution of resident and anadromous fish.

3. Uncertainties exist as to the level of harvest resident and anadromous fish can sustain without impacting the viability and productivity of the population. (CBFWA). The level and pattern of stock specific mortality due to harvest activities e.g., of various patterns of mixed-stock fishing, is uncertain. (WDFW)

4. What new harvest strategies can be employed to increase harvest opportunity while considering harvest mortality impacts on individual populations? (WDFW)

The Council's Research Recommendations:

6.1 Determine how to base sustained-yield management of a fish populations on numerical spawning escapement goals at the watershed level, which represent the productive capacities of the habitats for fish populations.

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

6.3 Evaluate appropriateness of stocks used in weak stock management.

6.4 Determine the origin and the temporal and spatial distribution of wild fish.

6.5 Evaluate selective harvest technology.

INSERT - research recommendations from the ISAB Harvest Management review April 2005.

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation

Harvest remains the primary reason for hatchery programs in the Columbia River Basin. This is especially true in the lower river, whereas the purpose of upper river programs appear more evenly divided between harvest and conservation. Upriver bright fall Chinook salmon and sockeye salmon populations are not largely supported by hatcheries.

Yet the management of fisheries on mixed hatchery and wild stocks is believed to have contributed to the decline of natural production in the Columbia Basin. Because of declining natural production, those fisheries that still harvest Columbia River salmon are largely supported by hatcheries.

Whether hatcheries are intended solely to produce fish for harvest may be used to create a replacement for the lost or diminished stocks is a significant policy. How hydropower-caused losses or reductions in numbers of naturally producing stocks should be mitigated into the future?

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

Recovery Planning

Overview: Fish and wildlife species and populations are characterized by life history, ecological, behavioral, phenotypic, and genetic diversity. Such diversity buffers fish and wildlife populations against short- and long-term environmental variation and has become more important as human activities have increased the rate and amplitude of environmental fluctuations over those that occurred historically. Human-caused development has altered the

organization of fish and wildlife populations and consequently probably altered metapopulation organization. This has very likely caused losses in adaptive capacity and resulted in a reduction in regional stability of production. Nevertheless, fish and wildlife populations in the Columbia River today can still form the base for rebuilding population abundance and diversity e.g., the importance of local adaptation to salmonid populations has been underestimated.

Populations are often the fundamental unit of viability analysis, so effectively evaluating the status of a species may depend on correctly understanding its population structure. For restoration and recovery actions to succeed, there must be understanding of how these distinct populations individually respond to environmental variables that are likely controlled by very different limiting factors. Sub-watershed and site-specific restoration and recovery actions must be tailored to specific populations and to their particular environmental and biological attributes (CENR, 2000).

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

Under unconstrained conditions, metapopulation structure would act to stabilize losses of diversity and reproductive fitness within individual populations. Present restoration efforts have focused primarily on remaining satellite populations, which are smaller and less productive and may have higher probabilities of extinction than core populations. This may have rendered present metapopulation organization more sensitive to the effects of regional variation by reducing metapopulation size, increasing local population extinction rates, and reducing dispersal between populations.

Bull Trout - Recent work on regional patterns of genetic variability and evolutionary relationships has been helpful in identifying major population groupings. Yet gaps in our understanding of the phylo-geography of bull trout remain. Additional research in this area would be useful for understanding patterns at a finer scale. This finer-grained genetic information would enhance understanding of the distribution of diversity within bull trout, and inform planning for reintroductions. A more concerted effort to standardize marker sets (e.g., micro-satellite primers) among labs would also be useful.

In addition, the impact of hydropower facilities on bull trout and their habitat must be evaluated. These studies should be done in conjunction with studies on bull trout from adjacent recovery units, e.g., Imnaha-Snake, Clearwater, Tucannon, Hood River, to determine areas of overlapping use and possible interactions. Research is also needed to determine the migration timing and pathways in and between tributaries.

As bull trout recovery actions are implemented such as fish passage at Condit Dam, bull trout will likely increase their use of the mainstem Columbia and Snake rivers. As a result, the need for research to investigate problems associated with fish ladder use, entrainment, spill, flow attraction, and water quality will become more important as recovery proceeds.

Predation - Poor habitat conditions; i.e. less cover, warmer water, poor water quality, can result in increased exposure to predation or decreased ability to avoid predators due to less refugia or slower reaction times. Consider a system where the habitat is poorly managed and large numbers of smolts are direct stream released become food for the intermediate predators such as bass and sunfish. Conversely, where the larger predators are intact and sufficient refugia exists, the smolts have the cold-water advantage; i.e., they are faster in cold water than their predators, but slower in warmer water. Yet with more fish in the estuary and marine system, more predators will survive downstream. A mass-balance model could address this. (Confederated Tribes of the Umatilla)

Management Needs:

1. Can the diversity of anadromous salmonid stocks be sustained over the long term? (Council Document SRG 93-2). Explicitly recognize the importance of stock diversity in all aspects of the restoration effort.

2. What is the relationship between genetic diversity and ecological performance? (Confederated Tribes of the Umatilla Indian Reservation)

3. Determine whether the loss of stock diversity reduced the fitness, and hence survival rate, of remaining populations.

4. What is the baseline level of genetic diversity necessary to maintain sufficient "canvas" for adaptive behavior? (Confederated Tribes of the Umatilla Indian Reservation)

5. Ascertain whether monitoring and evaluation can determine if certain life history types are favored, or selected against, by specific restoration actions. Identify strong, weak, and at-risk native populations and determine what actions can be taken to preserve and protect native populations.

6. Determine the loss of meta-population structure caused by increased mortality rates.

7. Determine which recovery approaches will be most effective in regaining meta-population structure that will increase viability.

8. Develop a set of precise quantitative definitions that link ESU, "independent population", and "subpopulation." Develop a set of decision rules indicating how viability will be assessed for "independent populations," how the viability of component independent populations," within an ESU will determine ESA status for that ESU, and what burden of proof will apply to setting boundaries of "independent populations," when the data are incomplete and the conclusions uncertain. (U.S. Forest Service)

9. Determine whether adoption of an anti-degradation policy; i.e., protecting the best remaining water, habitat quality, or natural wild stock production, is necessary for avoiding jeopardy and achieving recovery.

Critical Uncertainties: In order to identify and conserve aquatic diversity and integrity, it will be necessary to define the appropriate scales necessary to understand the distribution, resilience, and persistence of native aquatic species. A growing body of theory and empirical evidence suggests that localized persistence and resilience of species in aquatic ecosystems will be understood only within a broader spatial and temporal context. A better understanding of the dominant processes influencing the distribution, interconnection, and dynamics of populations through time and space requires work at multiple scales, especially at larger scales than typical of past research.

The cumulative effects of predation must be evaluated including marine mammals, avian species such as terns, cormorants, mergansers, as well as piscivorous fish including pike-minnow, walleye, and smallmouth bass. The increase in avian and fish predation in the Columbia and Snake Rivers is a result of how the river is managed. For example, predation rates are much higher under low flows than under higher flows, and under low flows, additional habitat is made available for predators e.g., more island space, lower velocities for fish predators. Predation-related research should focus on causes such as low flows and dredging that create avian predator habitat. (CRITFC)

The Council's Research Recommendations:

Viability of ESUs

7.1 Determine how to relate measures of diversity to integrated demographic metrics that directly relate to persistence of one or many populations.

7.2 Conduct research and monitoring to improve the reliability of viability assessment methods for salmonids.

Salmonids

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

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

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

7.5 Determine whether re-establishment of metapopulation structure between Columbia Basin salmonid populations would slow or stabilize the loss of diversity in isolated local populations.

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

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

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

White Sturgeon

7.9 Continue research and monitoring programs on life history, habitat requirements for all life-stages, population status, and trends of the Kootenai River white sturgeon. (USFWS)

7.10 Identify white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing in Kootenai River basin waters. (USFWS)

7.11 Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats. (USFWS)

7.12 Continue to research and develop a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon that includes protocols on brood-stock collection, propagation, juvenile rearing, fish health, genetics, and stocking. (USFWS)

7.13 Continue to monitor water temperature profiles in the south end of Lake Koocanusa during May and June to provide information necessary for timing to sturgeon spawning/rearing flow augmentation. (USFWS)

7.14 Design and conduct those studies necessary to determine the effects of Libby Dam operations and other threats on sturgeon life history, and the cause(s) of sturgeon mortality. (USFWS)

7.15 Evaluate the effects of contaminants and possible additional biological threats, e.g. predation and species composition, on Kootenai River white sturgeon and their habitats. (USFWS)

Lamprey

7.16 Determine the status, limiting factors, and management alternatives for anadromous and resident lamprey.

- Develop methods to differentiate among species at all life stages.
- Develop standardized sampling protocols and conduct systematic basin-wide surveys to assess adult and juvenile abundance and distribution.
- Define, improve, and continue historic distribution and abundance indices (e.g., dam counts, tribal harvest records, smolt trap collections, etc.).

7.17 Determine limiting factors for anadromous and resident lamprey.

- Document habitat preferences and habitat availability for all life stages of anadromous lamprey.
- Evaluate the physiological and behavioral responses of lamprey to a variety of environmental stressors e.g., capture and handling, elevated temperatures, contaminant exposure, sedimentation.
- Assess trophic relationships e.g., predation by exotics, reduced host availability.

7.18 Determine passage requirements for anadromous and resident lamprey.

- Identify potential obstacles to passage e.g., loss of recruitment upstream from a potential obstacle, observation of lamprey aggregations or mortalities at potential obstacles during migration periods.
- Assess passage efficiency, direct mortality, and/or other metrics that relate to loss of fitness; i.e., stresses or injuries that reduce ability to reproduce.
- Determine the specific structures or operations that delay, obstruct, or kill migrating lamprey.
- Develop aids to passage e.g., modify structures or operations, provide lamprey-

specific fishways, or bypasses.

7.19 Identify the biological and ecological processes important to anadromous and resident lamprey.

- Understand the ecological function of anadromous lamprey e.g., predator/prey relationships, linkages to other aquatic and terrestrial organisms.
- Understand the biology of anadromous lamprey e.g., reproduction, feeding.
- Develop methodology for gender identification in the field and laboratory e.g., identify spawning sex ratios, sex related behavioral characteristics.
- Develop aging techniques.
- Assess life history characteristics of freshwater and ocean-phase anadromous lamprey e.g., age, growth, timing of metamorphosis, movement, basin-specific comparisons.

Bull Trout

7.20 Characterize, conserve, and monitor genetic diversity and gene flow among local populations of bull trout that use the mainstem Columbia and Snake rivers. (USFWS)

7.21 Conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery tasks. (USFWS)

7.22 Determine the current, and future, role of the mainstem Columbia and Snake rivers in the recovery of bull trout. (USFWS)

7.23 Determine the effectiveness and feasibility of using artificial propagation to aid bull trout recovery in the Columbia and Snake rivers. (USFWS)

7.24 Determine the current extent of bull trout distribution and seasonal use areas. (USFWS)

7.25 Determine the movement and seasonality of use of different habitat types in the Columbia and Snake rivers by adult and sub-adult bull trout. (USFWS)

7.26 Determine the impacts of hydropower facilities on bull trout and their habitat should be evaluated, e.g., fish ladder use, entrainment, spill, flow attraction, and water quality. (USFWS)

7.27 Determine juvenile dynamics and capacity for each sub-population of bull trout and the dynamics for emigrants and Lake residents. (Montana)

Predation

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

- Evaluate and document the impact of predation in the mainstem in terms of numbers of ESA- listed fish taken, and estimated impact on smolt-to-adult return ratios.
- Improve the estimates of the impact of pinniped predation on salmonid stocks and on the recovery of depressed stocks.

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

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

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

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:

Who: NOAA, U.S. Fish and Wildlife Service, Bonneville Power Administration, U.S. Army Corps of Engineers, U,S, Bureau of Reclamation

The ESA requires that recovery plans contain objective, measurable goals for delisting; a comprehensive list of the actions necessary to achieve the delisting goals; and an estimate of the cost and time required to carry out those actions.

NOAA - In addition, NOAA Recovery Planning Guidelines suggest that recovery plans include an assessment of the factors that led to population declines or that are impeding recovery, hence the need for related research. Finally, it is important that the plans include a comprehensive monitoring and evaluation program for gauging the effectiveness of recovery measures and overall progress toward recovery.

The list of research recommendations include a number of tasks that are, or will be, addressed in processes such as by the Technical Review Teams and other processes which are contributing more appropriately to development of Recovery Plans. To implement these elements of recovery, NOAA Fisheries has formed geographically based Technical Recovery Teams (TRTs), in coordination with existing science teams and ongoing conservation planning efforts. The TRTs are technical workgroups convened and chaired by NOAA Fisheries to determine the preliminary biological criteria necessary to ensure the viability of Evolutionarily Significant Units, or ESUs, listed under the ESA.

The TRTs will provide technical support and analysis to these efforts and have been convened for the Puget Sound and Willamette/Lower Columbia/Southwest Washington regions, and the Interior Columbia River Basin. The TRTs will develop products that:

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

After population identification, the next step in the technical recovery planning process is to develop biological criteria for population and ESU viability. In determining biological viability criteria, the NOAA Technical Recovery Teams, or TRTs, generally follow the guidelines discussed in the *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (NOAA Technical Memorandum NMFS-NFWSC-42, June 2000). According to NOAA Fisheries, recovery goals must, at a minimum, restore listed ESUs to levels at which they are no longer threatened and can therefore be de-listed under the ESA.

NOAA Fisheries is also working with state, local, regional, tribal, and private entities to develop a collaborative recovery planning process for each planning area. The collaborative recovery plans will focus on identifying the measures and actions necessary to achieve the recovery goals identified by the TRTs. NOAA Fisheries believes it is critically important to ground the recovery planning process in the many state, regional, tribal, local, and private conservation efforts already underway throughout the region, such as subbasin planning. NOAA has also published a guidance outlining an integrated watershed approach to recovery planning. (see NOAA Ecosystem Recovery Planning for Listed Salmon: An Integrative Assessment Approach for Habitat. NOAA Technical Memorandum NMFS-NWFSC-58

http://www.nwfsc.noaa.gov/publications/techmemos/tm58/tm58.pdf).

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

Monitoring and Evaluation

In tandem, research and monitoring are two program elements that provide the basis for evaluation. Although often associated, they are different types of activities.

> *Monitoring data can describe what happened; research is often needed to help explain why and how it happened…. Monitoring involves measuring and sampling physical, chemical, and biological attributes of the resources. Research involves analysis or experiments to establish mechanisms that explain observed correlations.*
>
> -- Comprehensive Monitoring, Assessment and Research Program, CALFED, 1999.

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

The CENR (2000) report recommended that research efforts in the area of monitoring and evaluation would greatly enhance the scientific credibility of fish and wildlife restoration efforts and recovery planning by providing timely feedback to managers and policy makers. If properly designed, monitoring can help identify limiting factors to salmon recovery and provide feedback

to managers and to the public about how management plans and activities are affecting species and the environment. Monitoring also provides the basis for establishing program priorities, and for ensuring accountability for program expenditures. Thus, monitoring and evaluation provides the mechanism for reducing the uncertainties that undercut the effective implementation of the Program.

The results of monitoring and evaluation can facilitate the prediction of the effects of specific restoration actions, which will help direct management of the Fish and Wildlife Program as well as threatened and endangered species. Monitoring can also provide a basis for evaluating the relative effectiveness of how restoration dollars are spent. Research in support of the development of a risk-based monitoring strategy would enhance credibility of restoration, be sensitive to increase in risk, and would show improvements better than traditional methods.

Several of the research recommendations for monitoring could be presented under one of the other subject areas in Chapter II, e.g., hatchery related monitoring questions could be presented with hatchery research questions. Instead, monitoring and evaluation is presented as a dedicated subject area, because it is a process element of the program that must underpin all subject areas. The focus of the research is on techniques to improve the monitoring process, and some key regional monitoring needs.

Traditionally, monitoring in the Fish and Wildlife Program has been conducted to evaluate work at the project scale, across all subject areas. While work at this scale has intrinsic value, 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. A decade ago, the Scientific Review Group stated:

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

Consequently, this section sets forth the research needed to support the development of a regional approach to monitoring.

Overview: In the Columbia River Basin monitoring has been categorized in a hierarchical sequence (Tier 1, Tier 2, or Tier 3) in the All-H Paper and repeated in the 2000 Biological Opinion. The three levels are: trend monitoring (Tier 1), statistical monitoring (Tier 2), and research monitoring (Tier 3). The value of research, monitoring and evaluation is greatly enhanced if these elements are integrated. The differences between research and monitoring and evaluation are often difficult to differentiate, especially for large-scale questions, e.g., hydrosystem and habitat actions. In cases where actions are based on the extrapolation of results from small-scale research projects, they constitute research on a larger scale and may require long-term monitoring. Understanding the effect of habitat conditions on the performance of fish and wildlife populations requires replicated observational studies or intensive research level experiments to be conducted at large spatial and long temporal scales. Few evaluations of tributary habitat in the Columbia Basin meet these criteria.

In their report, Review of Strategies for Recovering Tributary Habitat (ISAB 2003-2), the ISAB recommended that intensive watershed monitoring at selected locations be included in overall strategies for evaluating habitat improvement projects. Understanding the effect of habitat conditions on salmonid population performance requires replicated observational studies or intensive reach level experiments at large spatial and temporal scales. Few evaluations of tributary habitat in the Columbia River basin have successfully adopted either approach.

The expense and effort needed to obtain the data necessary for evaluating the response of fish and wildlife to habitat restoration is considerable. It is likely to require several generations of a population to get statistically supported answers to questions about the effectiveness of habitat restoration. This supports an approach of focusing intensive monitoring efforts on a relatively few locations and to involve multiple parties in a collaboratively conducted and funded research effort (see Washington Salmon Recovery Funding Board. 2003a). This type of research has already begun in the context of the Federal RME pilot studies (Jordan et al 2003, Hillman 2004; WA SRFBa; and WAIMW 2004). By implementing these evaluations with clear objectives, careful employment of experimental and statistical design, disciplined adherence to the experimental constraints in treatment and reference sites, and patience, results can be obtained that will greatly improve the ability to ensure viable fish and wildlife populations.

Coordinating the implementation of multiple projects is an important concept and has been discussed in other documents. For example, ESSA's multi-watershed analysis of the effectiveness of past restoration actions in the Columbia River Basin (Innovative project #34008) provided strong empirical support for the importance of this idea (Marmorek et al 2004, http://www.efw.bpa.gov/fishreports///cgi-lib.1124.1). Furthermore, the Washington Salmon Recovery Funding Board (WA SRFB 2003b) projects also provide examples of prospective and retrospective research into this issue. Multi-watershed approaches can accelerate learning about effectiveness.

There are a number of disparate efforts in the region to coordinate and collaborate around monitoring and evaluation but there has been a distinct lack of a central or organizing principle for these efforts. Consequently, the Council's has worked to accelerate the development of more regional scale and scope monitoring and activities through Pacific Northwest Aquatic Monitoring Partnership. The components of the Research Plan that offer critical support for regional monitoring and evaluation are its long-term vision and its organization around biological concepts rather than a limited suite of management questions.

Management Needs: 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 deployed that permit monitoring results to be "rolled up" to provide scientifically defensible evaluations of whether the aquatic 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.

1. The primary research needed for monitoring is to develop data collection methods that will

result in a common currency for statistical valid analyses.

2. The region needs a coordinated approach to monitoring at different scales to ensure consistency in data collection and to provide a basis for "rolling-up" data to higher scales in order to answer evaluation questions at a programmatic scale.

3. Understand the collective and cumulative impacts of fish and wildlife management decisions across the Columbia River Basin.

4. Evaluate the performance of various management techniques and the development of an informed "best management practices" inventory.

5. Develop scenarios of future change based on alternative management prescriptions and forecasts.

6. Determine what methods will be most efficient and effective in detecting and measuring changes due to program activities. (WDFW)

7. Develop a programmatic approach for reporting on status, trends, and performance to a variety of stakeholders.

Critical Uncertainties:

1) Fish population status and trend data (abundance, distribution, and productivity of all Columbia basin populations) requires further development. This requires regional cooperation and joint funding of standard monitoring designs and monitoring programs to obtain more expanded, robust, and accessible information on adult escapement and smolt production.

2) More monitoring is needed to determine the indirect, delayed, or unaccounted-direct mortality levels associated with harvest. This information needs to be combined with more advanced and conservative harvest management assessment and allocation techniques.

The Council's Research Recommendations:

Watershed Condition Monitoring

8.1 Develop a spatially balanced survey design and integrated sampling strategy that allows the aggregation of data at multiple landscape levels over the PNAMP area to which participants will tier their watershed condition surveys.

8.2 Identify a core set of attributes and protocols that state, federal, and tribal monitoring programs will use for assessing status and trends in watershed condition.

8.3 Identify and implement a process for developing/refining common GIS layers.

8.4 Develop a sound Tier I trend-monitoring procedure based on remotely sensed data obtained from sources such as aerial photography or satellite imager for monitoring riparian vegetation, channel change, etc. (USFS)

8.5 Develop and implement a long-term statistical monitoring program (Tier 2) to evaluate the status of fish and wildlife populations and habitat. This action would entail development of

probabilistic (statistical) site selection procedures and establishment of common protocols for cost-effective "on the ground" or remotely sensed data collection of a limited number of indicator variables.

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

Effectiveness Monitoring

8.7 Develop a short list of high-level indicators of salmon recovery and watershed health at a third field level that can be aggregated to state and regional levels.

8.8 Develop a regionally acceptable standard for obtaining statistically valid samples of habitat restoration projects to say with certainty that the projects sampled represent the effectiveness of the project category as a whole.

8.9 Develop a list of habitat restoration project categories that if designed and constructed using documented BMP criteria are considered effective.

8.10 Identify attributes and protocols that state, federal, and tribal monitoring programs will use for assessing project effectiveness.

8.11 Strategically place intensively monitored watersheds throughout the Pacific Northwest to monitor and evaluate cause and effect relationships between habitat changes and fish abundance.

Fish Population Monitoring

8.12 Identify field sampling attributes and protocols that state, federal, and tribal monitoring programs will use for assessing status and trends in fish abundance, other biological indicators, and harvest.

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

8.14 Improve monitoring of smolt to adult return ratios of some stocks e.g., sub-yearling Snake River fall Chinook evaluations need to be improved. (CRITFC and USFWS)

8.15 Develop prediction models for bull trout and westslope cutthroat trout populations in the Flathead and Kootenai River drainages e.g., age-structure and environmental covariates. (Montana)

Hydrosystem Monitoring

8.16 Continue to determine juvenile hydro survival (priority total system/secondary in-river) in relation to performance standards. Determine the relative proportion and survival of migrating juvenile salmonids passing through the various passage routes, including spillways, located at the mainstem dams.

8.17 Continue to determine the effectiveness of transportation versus in-river migration. Determine the differences in migration timing and relative survival for transported and inriver juvenile salmon and steelhead.

8.18 Determine the relationship between ratios of transport and inriver return rates and measurements of juvenile survival (D values).

8.19 Determine the biological and physiological effects on wild and hatchery juvenile salmonids migrating through the mainstem dams that are exposed to stress from bypass, collection,

and transportation at the mainstem dams.

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

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

8.22 Continue to determine how specific operations, flow, and spill conditions affect fish and wildlife species downstream of dams. (CBFWA)

8.23 Develop and implement a monitoring plan to evaluate the effectiveness of management actions implemented as a result of the Total Dissolved Gas and temperature TMDLs established by EPA on the Columbia River. (Washington)

Hatchery Monitoring

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

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

Harvest Monitoring

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

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

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation

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

Rather than try to design a complete and comprehensive monitoring program, which it probably cannot afford, the region should identify and develop consensus about how much and what types of monitoring are needed, and can be afforded, for managing an effective fish and wildlife restoration program. All opportunities to conduct collaborative research on monitoring should be fully exercised. Regional coordination and cost sharing on tributary monitoring and research of habitat conditions, fish, habitat action effectiveness, and critical uncertainties should be addressed up-front in the overall vision of the plan and its longer-term implementation.

For example, the effectiveness research being conducted in pilot watersheds under the Fish and Wildlife Program is highly analogous to work in Puget Sound under the Pacific Coastal Salmon Recovery Fund. Further, the Bonneville Environmental Foundation has recently inaugurated similar work. These three corollary efforts, being conducted by separate entities indicate the need for coordination at a broad scale. The issues of scientific leadership, institutional innovation, and governance are being addressed by the Pacific Northwest Aquatic Monitoring Partnership in regards to the prioritization, design, and coordination issues for large-scale monitoring linked to management experiments.

Pacific Northwest Aquatic Monitoring Partnership

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

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

This Research Plan includes research recommendations from the Monitoring Strategy developed by PNAMP, because the Council, and the majority of parties to the Regional Research Partnership have signed the PNAMP Charter. PNAMP's coordination strategy takes into account the major funding sources, including the two major federal sources – the Pacific Coast Salmon Recovery Fund, and the Bonneville Power Administration's funding to the Council for its Fish and Wildlife Program. The Council's Research Plan recommends that the coordination of state research, monitoring, and evaluation activities under these two programs take place through PNAMP.

The Chair and the Coordinator of the Federal Caucus recently asked PNAMP for assistance in developing an approach to monitoring that can support eventual de-listing decisions. PNAMP responded affirmatively, and asked that the Caucus make the request formally via a letter that

would detail the needed elements of the approach. This is an example of how PNAMP can contribute significantly as a forum for recommending strategies for sharing and networking research and monitoring efforts and multi-agency funding agreements. The effectiveness of PNAMP coordination will rely on agency level commitments to support a strong top-down, programmatic framework; existing bottom-up approaches that can contribute will need to be modified to fit within this framework. For these reasons, the Council supports a top-down approach to regional monitoring that meets the bottoms-up approach (typified by the existing portfolio of ongoing projects) halfway by the time of the next implementation funding decision process.

Collaborative Systemwide Monitoring and Evaluation Project

The Collaborative Systemwide Monitoring and Evaluation Project, or CSMEP, is an example of an ongoing "on the ground" project to build collaborative partnerships between state, tribal and federal agencies across the Columbia River basin in order to develop and implement improved and coordinated monitoring and evaluation programs and protocols. This project is a collaborative effort, led by the Columbia Basin Fish and Wildlife Authority (CBFWA). It is co-sponsored by the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), four state fish agencies (WDFW, ODFW, IDFG, MFWP), the Fish Passage Center (FPC), and the Columbia River Inter-Tribal Fish Commission (CRITFC). It also involves members of PNAMP, WA SRFB, Federal RME, and the Action Agencies.

CSMEP has a strong technical focus on fish monitoring, and is actively coordinating with PNAMP to define their respective roles in improving monitoring and evaluation in the Columbia River basin. CSMEP and PNAMP are currently coordinating on how best to allocate effort between their respective levels of expertise to address this question. Eventually the project may function as PNAMP's technical group for fish monitoring and evaluation.
The project focuses on the issue of systemwide monitoring and evaluation of fish status, addressing requirements of NMFS and USFWS Biological Opinions and Recovery Plans as well as the NWPPC Fish and Wildlife Program. It proposes an integrated effort by fisheries scientists and biometricians to:

1) Document, integrate and make available existing monitoring data that bear on the problem of evaluating the status of salmon, steelhead, bull trout and other species of regional importance across the Columbia River Basin;
2) Work collaboratively to critically assess the strengths and weaknesses of existing monitoring and evaluation methods for answering key questions regarding both stock status and responses to management actions; and,
3) Work collaboratively to design improved monitoring and evaluation methods that will fill information gaps and provide better answers to these questions in the future.

(Additional information on CSMEP and its products CSMEP can be found at: http://www.cbfwa.org/committees/csmep/default.cfm.)

Federal Research, Monitoring, and Evaluation Plan

In NOAA's 2000 biological opinion, monitoring and evaluation was a strong and central theme. Over a two year period, Bonneville, the Corps, and the Bureau of Reclamation work with NOAA Fisheries to develop a *Research, Monitoring, and Evaluation (RME) Program for the NOAA Fisheries 2000 Federal Columbia River Power System (FCPRS) Biological Opinion and a Columbia River Federal Salmon Recovery Strategy MOU*. Recommendations for research relevant to monitoring and evaluation and the hydrosystem identified in the RME plan are reported in this Research Plan. The ISRP reviewed the plan and issued Review of Draft Action Agency and NOAA Fisheries RME Plan (2004-1), which made several recommendations for revisions to the plan.

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

Pacific Coastal Salmon Recovery Fund

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

The recovery of sustainable salmon populations will likely take decades, and require a substantial investment. Nonetheless, it is important to track the work accomplished by current investments and measure activities and changes on a regular basis. NOAA Fisheries has developed a comprehensive performance measurement system for the PCSRF in conjunction with the states and tribes in response to requests by Office of Management and Budget and Congress for program accountability. The MOUs between NOAA Fisheries and the states and tribes, which previously established criteria and goals for prioritizing PCSRF project funds have been amended to include these program-wide performance goals and reporting metrics. It is anticipated that the use of these project level reporting metrics, combined with larger scale watershed and subbasin assessments, and results from monitoring and evaluation efforts, will facilitate long term assessments of program effectiveness in terms of increased numbers of salmon. (Bonneville is currently adopting these metrics into its project tracking system.)

Bonneville Environmental Foundation

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

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

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

Emerging Issues

The emerging issues includes several topics that warrant attention, but are not being managed by other regional planning forums that support the Fish and Wildlife Program or recovery planning. The emerging issues affect anadromous fish, resident fish, and wildlife include the implications of climatic effects, toxic contaminants, invasive species, and the impacts of human population expansion. These are issues for which there is leadership at the state and national level, but not at the regional level. Consequently, they are raised here because they include important management questions for the Fish and Wildlife Program; and, are generally neglected within the scope of most other regional plans. Because the emerging issues encompass broader federal and state resource management issues, it is incumbent upon the Regional Research Partnership to develop implementation scenarios in which parties other than the Council will have leadership roles and responsibilities, and a substantial cost-share.

Impacts of Climate Change on Fish and Wildlife Restoration

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

freshwater conditions, due to reduced precipitation, low stream flow, and increased stream temperatures, tend to be concurrent.

Management Needs:

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

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

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

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:
This section will be completed based on the ISAB Harvest Management review that will be completed in April 2004.

Toxics

Overview: Environmental contaminants such as heavy metals, pesticides, petroleum, and related petrochemical compounds pose a substantial threat to some aquatic ecosystems. Fish are vulnerable in rivers and lakes draining watersheds that support irrigated agriculture, mining, fossil fuel power generation, large municipal and industrial complexes, and other concentrated sources of human activities. Managers require contaminant surveys and bio-monitoring to detect the occurrence and bioaccumulation of suspected contaminants.

It is important to integrate chemical processes into the "habitat" perspective, especially for agricultural and urban watersheds as they are critical determinants of habitat quality. Otherwise, restoration projects will continue to make the landscape appear restored, without addressing the health of the underlying ecosystem. The challenge of the urban stream restoration should be viewed as a case study in fish and wildlife habitat restoration. On a larger scale, various studies have shown that anthropogenic contaminants may have deleterious impacts on the health of fish in the Columbia River Basin e.g., the results of the Bio-monitoring of Environmental Status and Trends (BEST) Program have been reported by Hinck, et al., (2004).

The USGS has developed a body salmon-specific eco-toxicological literature, surface water monitoring reports, and related documents under the National Water-Quality Assessment

Program. Distribution of dissolved pesticides and other water quality constituents in small streams, and their relation to land use, has been examined in the in the Willamette River Basin, Oregon, by Anderson et al. (1997). The seasonal and spatial variability of nutrients and pesticides in streams of the Willamette Basin, Oregon were reported by Rinella and Janet (1998). Water quality in the Willamette Basin, Oregon has been reported by Wentz et al. (1998). The occurrence and an assessment of factors affecting concentrations and loads of pesticides in the surface waters of the Yakima River Basin, Washington, has been reported by Ebbert and Embrey (2002). Thus, information is available that documents both environmental conditions in the Columbia River Basin in regards to exposure as well as response; i.e., adverse toxicological impacts on salmon and/or their habitats. In addition to the issues of persistent and bio-accumulative legacy pollutants, the current use of pesticides and the various contaminants associated with agricultural and urbanizing watersheds in the present-day Columbia River Basin, must also be examined.

Water column data collection is an important part of the assessment of toxics in the Columbia River Basin. Water column data should be collected and analyzed to detection limits that are comparable to values found in Oregon's Table 20, typically ng/L values (see: http://www.deq.state.or.us/wq/wqrules/Div41/OAR340Div41Tbl20.pdf).

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

The region must determine how to develop a research, monitoring and evaluation program for toxics and contaminants. A major information gap is the lack of a "relative risk model" to extrapolate potential contaminant risk to fish and wildlife in the many areas where there is little of no data. This topic will be discussed in a workshop convened by EPA and NOAA Fisheries and hosted by the Council in April 2005.

Management Needs:

1. What is the extent of toxic contaminants in fish and wildlife in the Columbia River Basin?

2. How do these contaminants affect fish and wildlife survival and productivity?

3. How can we best detect and quantify fate and effects in the environment?

4. How significant is the impact of endocrine disrupters?

5. What are the effects of air pollution and acid rain on the fish and wildlife resources in the Columbia river basin?

Critical Uncertainties:

1. Although a considerable amount of information has been developed regarding exposure via surface water, sediment, and tissue monitoring, we know much less about toxicological response. While it is known that salmon are exposed to potentially toxic contaminants, it is unknown whether these exposures are causing adverse affects sufficient to undermine conservation and recovery efforts throughout the Columbia River Basin.

3. The sources and fluxes of contaminants in the Lower Columbia River estuary have not been characterized. Little information exists as to how fish and wildlife are being exposed, such as the relative contributions from upstream sources versus lower river off-channel sources versus hatchery feeds. Because of the critical nature of estuary use for several populations of Pacific salmon with different life histories, toxic contaminant exposure pose a significant uncertainty in considering recovery efforts for Columbia River stocks.

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

4. The extent of concentrations of toxic pollutants found in the sediments in reservoirs behind dams in the mainstem is unknown.

The Council's Research Recommendations:

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

10.2 Determine the biological consequences of contaminant exposure in anadromous and resident fish and wildlife.

- Determine the biological consequences of contaminant exposure for impacts on aquatic habitats and/or community structure e.g., prey species and higher trophic levels, such as piscivorous birds.
- Determine the exposure patterns of wild versus hatchery fish, in populations with different life histories and patterns of estuary use, in various listed ESUs.

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

10.4 Determine the pollutants and toxicity in the reservoirs behind dams in the mainstem, including water column, fish tissue, and sediment. (Oregon DEQ)

10.5 Identify and implement actions to reduce toxic contaminants from entering the Snake and Columbia rivers.

10.6 Identify alternative pesticides and non-pesticide management activities that can be used for the eradication of specific aquatic invasive species? (Oregon DEQ)

10.7 Determine potential nontarget impacts of management techniques, such as sub-lethal impacts of herbicides on juvenile coho and Chinook e.g. 2,4-D, fluridone, diquat, and triclopyr, relative to other chemical stressors that may be limiting salmon productivity.

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:

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

Who: U.S. Geological Survey - The U.S. Geological Survey (USGS) is comprised of four Divisions of Water, Biology, Geography, and Geology. Thus, the USGS has a strong interdisciplinary approach, and brings diverse and highly specialized scientific expertise to bear on research problems. The scientific mission of the Western Fisheries Research Center (WFRC) is part of the Division of Biology.

Who: NOAA -The core mission of the NOAA Ecotoxicology and Environmental Fish Health Program is to determine the impacts of human activities on the health of wild fish, especially Pacific salmon and marine fish. To do this, the program has five research teams, four of which focus on different aspects of fish physiology and biology, and one of which focuses on assessing risks posed to fish health by human activities, especially the releases of chemical contaminants into freshwater, estuarine, and marine waters.

How: EPA also implements water quality standards that are the foundation of the water quality-based control program mandated by the Clean Water Act. Water Quality Standards define the goals for a water-body by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. A Total Maximum Daily Load or TMDL, is a tool for implementing water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the allowable loadings or other quantifiable parameters for a water-body and thereby provides the basis to establish water quality-based controls. These controls should provide the pollution reduction necessary for a water-body to meet water quality standards. However, that EPA has not developed Alternate Concentration Limits for the vast majority of chemicals of concern for aquatic species, which decreases the applicability of TMDLs.

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

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

How: U.S. Geological Survey - WFRC conducts research on how ecosystem dynamics affect critical living aquatic resources in large river systems. The WFRC is active in the Columbia River Basin and maintains the Columbia River Research Laboratory near White Salmon, Washington. WFRC scientists have identified aquatic invasive species, effects of multiple stressors on Pacific salmon and other species, and a suite of habitat-species issues in the lower Columbia River/estuary as issues of great concern. WFRC is supporting the research needs of the U.S. Bureau of Reclamation, Army Corps of Engineers, and the Bonneville Power Administration. The WFRC is working with multiple collaborators in several large ecosystems, including the Columbia, Klamath, and Sacramento-Bay/Delta systems. WFRC is also working on contaminant projects with multiple partners, such as USFWS, U.S. Bureau of Reclamation, NOAA Fisheries, and the Water Resources Division of the USGS.

How: NOAA -While NOAA has expertise in ecotoxicology, there is substantial effort made to assess the normal physiology of wild fish, and natural variations in response to non-anthropogenic factors, as a backdrop against which human activities, such as the release of toxic chemicals, can be assessed. In addition to determining the effects of toxic contaminants on fish health, an important part of our research also examines the recovery of fish health after remedial activities are undertaken to clean up contaminated sites. This important line of research allows us to determine the efficacy of cleanup operations, and better determine the accuracy of our models, which predict risk to our living aquatic resources.

Invasive Species

Overview: For the purpose of this plan, invasive and native species are defined as following Section 1. of Executive Order 13112 on invasive species, as follows:

> (f) "Invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.
>
> (g) "Native species" means, with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

Invasive species comprise one of the most significant alterations of native ecosystems for fish and wildlife, and plants, and are rapidly becoming a dominant component of aquatic ecosystems within the Columbia River basin. As species become more dominant in the ecosystem they will have a greater impact on native fish and wildlife populations. A recent survey of aquatic nonnative species in the lower Columbia River found 81 aquatic nonnative species below Bonneville Dam http://www.clr.pdx.edu/projects/cr_survey/index.htm. A new survey, funded by USFWS, will be launched in 2005 to cover the mid-Columbia, below Priest Rapids Dam, and lower Snake Rivers, below Lower Granite Dam. Aquatic invasive species issues are not independent of other hydro-system issues, as management has the potential to influence invasions in ways that dramatically influence desirable species or conditions.

From a fisheries perspective, some of the most challenging long-term management problems will involve nonnative, invasive species. The most widespread invasive nonnative fishes in the west are rainbow and brook trout. These have been introduced to provide angling opportunities, including replacement of opportunities lost through hydro-system influences. There is a need for better assessments of the biological and economic consequences of these invasions. This would include research to identify patterns and consequences of invasions on species and ecosystems, monitoring protocols, and decision support tools. A key issue in the control of nonnative trout invasions is the conflict between fish passage restoration for native species, and the chance these restoration efforts may open the door for invasive species likely to be introduced to the Columbia River basin, such as New Zealand mudsnails, crayfish, other nonnative fishes such as northern pike, Atlantic salmon, and new diseases.

A proactive approach to anticipating invasions and identifying areas at-risk, could potentially save millions of dollars in future efforts to control species once they become established and threaten native fisheries. The region should heed the lessons learned from highly invaded areas like the Great Lakes. An extensive study of nonnative species in the United States (OTA 1993) found that intentional introductions of several taxa, including fish, have proven just as likely to cause harm as have unintentional introductions.

A number of studies of walleye, smallmouth bass, and channel catfish have been conducted. One of those studies by Zimmerman determined that these three species account for over 20 percent of juvenile salmon predation, and that smallmouth and walleye prey proportionally more on salmonids than do native pike minnows. It is likely that shad, yellow perch, bluegill and other sunfish, crappies, Eurasian milfoil, Asiatic clams (*Corbicula manilensis*), and other species effect juvenile salmonids and other aquatic biota, either directly as predators, competition, or indirectly by altering the food base, water chemistry, physical habitat attributes, etc.

Projects outside of the Columbia River Basin, particularly lake rehabilitation, have been successful in removing hybridized fish populations, creating genetic reserves for native fish, drastically improving fisheries, and eliminating source populations for further illegal introductions. However, there have been relatively few examples of success in eradicating established aquatic invasive species at an ecosystem level. Further, significant ecological and economic trade-offs occur when control is attempted. Past experience demonstrates relatively low levels of success in eliminating the impacts of well-established invasive species. While there are many important research questions regarding impacts and control of invasive species currently in the Basin, answering questions that will aid prevention and detection of new species

may be more urgent. Therefore, research should be conducted to support a risk analysis of significant potential invaders e.g., zebra mussels, and related preventive actions that can reduce those risks. Greater gains may be achieved by improving our ability to prevent introduction of new invaders e.g., silver carp, zebra mussels, Hydrilla, to the Columbia River Basin.

Attempts to control or mitigate for the effects of invasive species will only be effective if measures are in place that will curtail the introductions of new species. To date, methods to mitigate introductions via major pathways e.g., from ballast water or hull fouling, are in the process of being developed, thus, the efficacy of these measures is largely untested.

Management Needs:

1. Identify primary nonnative species introduction pathways and develop protocols and methodologies to limit new introductions.

2. Determine how to build capacity for prevention and early detection and rapid response to new invasive species.

3. Determine the current distribution and abundance of invasive and nonnative species to establish a baseline condition.

4. Determine the relation of the current distribution and abundance of invasive and nonnative species to existing habitat conditions including flow and temperature regimes.

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

6. Determine the extent that nonnative species affect native fish and wildlife species in the Columbia River basin.

7. Determine if environmental manipulations can be conducted in a manner to reduce likelihood of establishment, or to inhibit the growth and dispersal of invasive populations e.g., identify mechanisms to reduce or eliminate the reproductive capacity or dispersal of nonnative species in native salmonid habitats.

8. Determine areas of high nonnative predator abundance and their effect through entrainment and connected waterways.

9. Determine what the economic consequences of invasions, such as the effect of Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*), are throughout the system, on native species, recreation, lakefront property values, and power generation.

Critical Uncertainties: To determine whether species are, or are becoming, dominant in the ecosystem, initial baseline and monitoring information suitable to detecting trends in abundance

is necessary. There are a number of nonnative species in the Columbia Basin that lack sufficient data to determine if they are invasive from a population growth, dispersal, or impact standpoint. In the absence of basic information on the distribution and abundance of these species, and how these species interact with other components of the Columbia River ecosystem, the magnitude of the effect is unknown. In the absence of this basic information, focusing control and management efforts on species that likely have a large effect may not be possible. Even for species that have been determine to be invasive, willingness to remove that species may be influenced by positive impacts that some interests associate with it.

Habitat restoration may be ineffective at restoring native species where nonnative species are well established. Further, some types of habitat restoration activities may actually promote establishment of nonnative species by providing short-term disturbance regimes. Available science suggests that some nonnatives can be effectively suppressed where habitats maintain relatively natural streamflows, thermal regimes, habitat diversity, and intact native fish assemblages. However, these actions are usually only partially effective and only for the duration of the action. In the preceding section on toxics it was noted that sub-lethal effects on juvenile coho and Chinook may result from the application of herbicides, 2,4-D, fluridone, diquat, and triclopyr which are herbicides commonly used to treat invasive milfoil in Washington.

The Council's Research Recommendations:

Ecological Impacts

11.1 Identify the interactions between native and invasive species, including:

- Predators, prey, food chain organisms, pathogens, and those that alter habitat structure;
- How competitors respond to altered systems and to restoration and recovery actions; and,
- How food supplies have been altered and how they can be restored (CENR, 2000).

11.2 Determine the current distribution and abundance of invasive species to provide a baseline condition. (USGS)

- Determine the relation of the current distribution and abundance of invasive species in relation to existing habitat conditions including flow and temperature regimes. (USGS)
- Determine the environmental constraints on abundance and distribution of currently established or eminently threatening invasive species.

11.3 Determine the ecological and economic consequences of invasions on native fish fauna and aquatic organisms e.g. competition, predation, and cascading trophic effects on native species, nutrient cycling, effect of management activities. (Montana)

- Determine the impact of nonnative aquatic and terrestrial species that are invasive on salmonid recovery. (EPA)
- Determine the impacts of nonnative species invasions i.e., rainbow and eastern brook trout, on abundance, distribution, life history and genetic diversity on bull trout, redband trout, and westslope cutthroat trout populations. (Montana)

11.4 Determine the impact trophic impacts of nonnative species. Determine whether the

economic and ecological effects invasive species have greater impacts at some trophic levels or in specific guilds than others. (Battelle)

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

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

11.7 Develop and research whether the large numbers of cryptogenic species found in the lower Columbia introduced or native? (Battelle)

11.8 Develop and research the number and importance of introduced disease organisms, parasites (plant and animal) and aquatic insects in the lower Columbia. (Battelle)

Prevention

11.9 Determine primary nonnative species introduction pathways and develop protocols and methodologies to limit new introductions. (USGS)

11.10 Determine how low-density populations of invasive species can be detected i.e., new monitoring techniques and optimized search protocols.

11.11 Determine what factors limit invasive species in their native range, such as viruses, bacteria, fungi, parasites, predators. Determine the current extent of the colonization of reservoirs by non-native estuarine and mountain stream species and their role in reservoir food webs and headwater storage projects.

11.12 Develop risk analyses regarding species that have not yet established widely in the Columbia Basin, and the associated need for management strategies to reduce the risks of introducing invasive species of concern. (USFWS)

11.13 Develop rapid response methodologies to eliminate new nonnative species at the source of introduction before they spread and become unmanageable in the environment.

11.14 Assess the effectiveness of nonnative fish suppression programs on native salmonid populations; i.e., abundance, distribution, life history structure, and genetic composition and diversity). (Montana)

- Evaluate effectiveness of actions to control established species and to limit the introduction of new species by evaluating long-term trends in monitoring data. (USGS)

11.15 Determine the potential nontarget impacts of management techniques, specifically the sub-lethal impacts of herbicides on salmonids. Evaluate alternative pesticides for use in eradicating specific aquatic invasive species.

11.16 Determine how to reduce the impact of invasive species by environmental manipulations e.g., reductions in water temperature can reduce impacts from nonnative predators through physiological means although not necessarily reducing the predators numbers or dispersal.

11.17 Determine how presently established nonnative species e.g., shad, walleye, *Corbicula*, Eurasian watermilfoil, can be managed to minimize ecological and economic effects, including use of effective biological control agents.

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:

Who: 100th Meridian Initiative - The 100th Meridian Initiative is a cooperative effort between state, provincial, and federal agencies to prevent the westward spread of zebra mussels and other aquatic nuisance species in North America. The goals of this Initiative are to: prevent the spread of zebra mussels and other aquatic nuisance species west of the 100th meridian; and, to monitor and control zebra mussels and other aquatic nuisance species if detected in these areas.

How: Establish research program for identification of other pathways and risk evaluation which could cause introductions of Zebra mussels and other related aquatic nuisance species west of the 100th meridian. Evaluation of these pathways and development of specific plans of action to address these identified potential risk.
http://100thmeridian.org/

Impact of Human Development Patterns on Fish and Wildlife Restoration

Overview: Like climate change, the impact of an increasing human population in the Columbia Basin is a widely recognized issue but one that is rarely incorporated into fish and wildlife planning. The human population of the Columbia Basin is increasing rapidly, a trend that is expected to continue. This increase is not occurring uniformly across the basin, but is largely concentrated in and around urban areas and exacerbates anthropogenic impacts such as toxics. Urbanization and land use associated with an expanding human population is a contributing factor in salmonid declines and may be a significant barrier to recovery.

The growing population will potentially impact non-urban areas as well through increased recreation and housing in riparian and rural areas. At the same time, the economy of the region is shifting with the potential for both positive and negative impacts on fish and wildlife habitats. The ISAB has pointed out that the Council's program and the NOAA Fisheries restoration plans do not include consideration of these trends but, as with climate change, assume a level base case. Because the Council's Fish and Wildlife Program mitigates human impacts on fish and wildlife habitats, it is important to consider human demographic trends and their potential impact on fish and wildlife habitats. In April 2002, the Council asked the ISAB to provide an analysis of the projected trends and patterns in human population growth patterns in the Columbia Basin and how these might affect the success and direction of the Council's program.

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

The Council's Research Recommendations:

12.1 Determine whether salmonid populations in the Columbia River be increased and sustained over the long term, given the multitude of biological, physical, and cultural constraints? (Council Document SRG 93-2).

12.2 Clarify regional variation in the physical, biological, social, cultural, and economic environments of salmon (CENR, 2000).

INSERT - Summary Table of immediate research priorities as determined by the Regional Research Partnership.

Programs and Partners for Implementation:

Who: Pacific Northwest Regional Collaboratory - Pacific Northwest National Laboratory (PNNL) and the Institute for Natural Resources of Oregon State University are working to develop a regional sustainability decision support system to address these types of basin-wide information needs, through the Pacific Northwest Collaboratory (www.pnwrc.org). The Northwest Sustainability Atlas Project being conducted by Battelle and the Institute of Natural Resources addresses both geospatial research and applications, and is a potential vehicle for this work.

III. Implementing Research Recommendations

Chapter III summarizes research activity under the Fish and Wildlife Program in terms of the current allocation of program expenditures and the current allocation of research activity by topic. Finally, it compares the research activity currently being implemented under the Fish and Wildlife Program with the priorities identified by the Regional Research Partnership in order to help clarify current program support for research and to assist in identifying research gaps.

Allocation Under the Fish and Wildlife Program

The Northwest Power Act establishes Bonneville's obligation to fully mitigate for fish and wildlife impacts from the development and operation of the hydropower system. The Council recognizes its obligation, in turn, to develop a program that guides Bonneville's mitigation efforts and is staged to accommodate yearly budget limitations.

Current Allocation of Expenditures by General Category

The Council has adopted the following principles for allocating funding to address fish and wildlife impacts throughout the basin:

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

To prioritize among these needs, the Council's Project Funding Priorities in the Fish and Wildlife Program 2000 allocated funds by resource category; i.e., anadromous fish (70 percent), resident fish (15 percent), and wildlife (15 percent). The Council will maintain this allocation until a new budget allocation is adopted. The three-year average for 2001-2004 of expenditures for projects in support of anadromous fish, resident fish, and wildlife are reported in Table A.

Table A. Three-Year Average Expenditures by General Category for the Council's Fish and Wildlife Program.

BY GENERAL CATEGORY	Type Percent
Anadromous Fish	73%
Resident Fish	14%
Wildlife	5%
Program Support	8%
Regional Total	100%

The base percent figures for resident fish and wildlife are currently running at about half of the de facto allocation of 15%. Thus, while the Program includes a general allocation of expenditures to guide restoration activity by resource category, it may or may not adhere closely to that allocation in any particular funding cycle. However, this allocation was set forth to guide the overall program, not to guide research funding.

Current Allocation of Expenditures by Program Element

The three-year average for 2001-2004 of the allocation of expenditures to the elements of the Fish and Wildlife Program is presented in Table B., and enables comparison of expenditures for research with those for the other elements of the program.

Table B. Three-Year Average of Funding by Program Elements for the Council's Fish and Wildlife Program.

BY BUDGET COMPARTMENT	Compartment Percent
Information (Data) Management, Coordination, Administration	9%
Monitoring & Evaluation	22%
Research	8%
Mainstem	4%
Production	30%
Habitat	27%
Regional Total	100%

The funding figures for research in Table B. include research in support of all the topic areas identified in this plan except for those identified as emerging research topics. Please note that the other headings in this table e.g., for monitoring and evaluation, and habitat, are reporting figures for restoration projects, not research projects. In light of the many critical uncertainties facing the Fish and Wildlife Program, the figure of 8% of base funding for research appears modest.

Current Allocation of Expenditures by Research Topic Under the Fish and Wildlife Program

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

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

- The Council's Subbasin Planning initiative;

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

- The National Marine Fisheries Service's 2004 Consultation on Remand for the Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia River Basin; and,

- The Final Updated Proposed Action for the FCRPS Biological Opinion Remand.

Yet the Program does not set forth a dedicated allocation for any particular program elements such as research nor has the Council developed guidance on the allocation of funds by research topic. Instead, the Council has deferred to the directive of the Four Governors to develop this Research Plan in a manner that includes the convocation of a Regional Research Partnership. The Partnership will identify regional research priorities and recommend their implementation to its members, including the Council. The Council will then decide which of the recommend research priorities clearly fall under the responsibilities of Fish and Wildlife Program.

The three-year average expenditures by research topic for the Council's Fish and Wildlife Program are summarized in Table C. These figures were compiled from the research projects currently under the Fish and Wildlife Program listed in Appendix C. For the purpose of the summarization "research" was defined as work that sought knowledge that would have future and broad benefit. Thus, projects conducting monitoring for the sole purpose of evaluating work at the project scale were not deemed research, while project scale work that could have broad implications was considered research. Another example is that work by the Army Corps of Engineers on improving fish passage was defined as research, whereas work under the Fish and Wildlife Program testing the effectiveness of passage strategies was considered monitoring. Consequently, this approach may have missed research elements embedded within restoration, management, and monitoring and evaluation projects. In the future, the sponsors of restoration projects will be discouraged from proposing additional research and/or monitoring elements to their proposals. Concurrently, project sponsors will be encouraged to submit proposals for dedicated research projects; i.e., squarely addressing an identified regional research priority.

INSERT Table C. Three-Year Average Expenditures by Research Topic for the Council's Fish and Wildlife Program

[NOTE**:** To complete this section, update Appendix C., and then generate Table C. with the following headings:

Research Topic	Number of Projects	Type Percent

The intention of this section of the plan is to provide a couple different perspectives on how research fits into the program. More importantly, it is a set up piece for Table F. to identify knowledge gaps.]

Please note that the figures in Table C. only reflect Bonneville Power Administration's "direct funded" category, and do not include the Corps of Engineers approximately $40 million Fiscal

Year 2003 research budget for the "reimbursable funded" category (see Table D. below). Furthermore, Table C. does not include relevant research studies pursued under other tribal, agency, university, and private programs, nor does it portray historical research efforts, such as completed or discontinued projects.

The figures in Table C. report some, but not all of the twelve research topics presented in this plan, because the topics presented in Chapter II profile the potential future shape of the program, not the current state of the program, and so there is little activity under several of the topics. Some research topics are unique to a single topic e.g., ocean productivity and anadromous fish, while others, such as monitoring and evaluation, are relevant to all topics.

Current Allocation of Expenditures by Research Topic Under the Anadromous Fish Evaluation Program

Army Corps of Engineers expenditures for FY04 under the Anadromous Fish Evaluation Program (AFEP) are presented in Table D.

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

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

Scientists who work with "systems theory" often warn that trying to optimize one component, such as the mainstem, of a complex system like the Columbia River Basin 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.

Summary of Regional Research Priorities

The research priorities identified by the Regional Research Partnership at the end of each of the research topics profiled in Chapter II are summarized in Table E.

INSERT Table E. Summary of Current Regional Research Priorities

[NOTE: Insert Table E. after convening the Regional Research Partnership and completing a research prioritization exercise.]

Identification of Research Gaps

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

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

In response to these recommendations, this Research Plan addresses knowledge gaps in the following way. A "gap in knowledge" is considered to exist whenever a research priority set forth in Chapter II is not being addressed by a research project(s) under the Fish and Wildlife Program, by projects of the other members of the Regional Research Partnership, or another entity who will make results publicly available. A gap in knowledge can only be closed when sufficient results are accumulated and supportable conclusions are drawn from those results. Closing a knowledge gap may require a single project, several projects, or a program of projects, which may be funded by the Council; the Council in collaboration with other members of the Regional Research Partnership; solely by other members of the Partnership; or another entity who will make results publicly available. The competing demands on available Fish and Wildlife Program funding underscore the need for such deliberate, systematic and collaborative integration of current research activity with the priorities for future research.

It is important to note that implementing the priorities for new research identified in Table A may require a reallocation of research dollars between topics from one funding cycle to the next. The fact that the current spending allocation amongst research topics is disproportional does not in itself constitute a reason for reapportioning the allocation to achieve equity. The challenge is to focus the collective efforts of the Regional Research Partnership on the key priorities, irrespective of what topics they may address from one funding cycle to the next.

Recommendation: The allocation of research effort to specific topics should be made on the basis of the priorities identified by the Regional Research Partnership, and not be constrained by a static formula.

Assessment of the relevance of on-going projects to the research priorities identified in Table E. is presented in Table F. Table F. illustrates the extent to which regional research priorities are being addressed by current projects in the Fish and Wildlife Program and the resulting gaps in coverage. It is natural for these gaps to exist considering that this is the first effort to develop a set of regional research priorities and that the current pool of research projects developed over a long period of time in response to: long-standing objectives of the Council's Fish and Wildlife Program; Provincial Review project solicitations; and the requirements of the federal biological opinions and other planning documents.

[INSERT Table F. based on Table E.]

The results in Table F. were derived from an evaluation of each research priority identified in Table E., as "covered, partially covered, or not covered" by the Fish and Wildlife Program or the projects of the Army Corps of Engineers.

The purpose of Table F. is simply to convey a sense of current Fish and Wildlife Program, and Army Corps of Engineers projects, coverage of the compiled research priorities. The last column in Table F reports the number of research priorities not addressed by on-going or recent projects. Thus, Tables C. and D. portrayed current activity, while Table F. identifies gaps in knowledge that should be addressed through priority research.

Table F. also indicates that some of the research priorities set forth in Chapter II are already being addressed by current or recent projects. These projects are included in the table because in many cases funding will need to continue over more than one budget cycle to complete the research. Thus, they remain research priorities until the work has been completed.

Furthermore, some gaps may appear unexpectedly low for some research topics. Yet even a high degree of project coverage for some research priorities by itself does not mean that the hard work has been completed. More realistically, it means the existing projects provide a strong start on a research program. Current projects with strong connections to regional research priorities should be considered as vehicles for addressing the remaining knowledge gaps. Finally, the Council may also need to respond to rapidly emerging management uncertainties from time to time by identifying additional research priorities.

Getting Underway: Project Selection

This section briefly describes the operational context of the Fish and Wildlife Program, including a brief description of the project selection and funding process. This plan identifies what types of research to fund. It also provides a rationale as to why to fund specific work and general recommendations as when to provide funding. The draft Research Plan does not provide detailed guidance for project performance and administration. Bonneville has the primary responsibility for the implementation and management of research contracts pertaining to activities under the Fish and Wildlife Program, Finally, it explains how projects are selected and funded in the Fish and Wildlife Program, which does not fund all of the research needs of the region.

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. As a result, 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.

In 2000, the Council shifted from an annual funding cycle for projects to a three-year cycle. Because state and federal agencies remain on an annual funding cycle, it is difficult to make long-term funding agreements. Consequently, formal arrangements such as memoranda of agreements may be necessary to guarantee long-term funding commitments for selected large-scale field experiments. The Council must design the project selection process that will follow the adoption of subbasin plans in 2005.

Project Selection Under the Fish and Wildlife Program

The Northwest Power Act affords the Council broad discretion to define the procedures for conducting project review and selection for many projects funded by Bonneville. In general, the Act requires all projects to undergo an independent scientific review by the ISRP to ascertain their scientific and technical merits. The ISRP consists of eleven members assisted by a number of Peer Review Group members. The ISRP was created by amendment to the Northwest Power Act in 1996 and charged with providing scientific review of projects funded by Bonneville under the Council's program. Congressional report language subsequently expanded the role of the Panel to include scientific review of projects sponsored by the Corps and other federal agencies that are funded by Bonneville through reimbursement. The ISRP and the Council's review process have served to appreciably increase the level of scientific rigor in Bonneville projects and hopefully have increased the effectiveness of projects to meet the Program's vision. In addition to the ISRP, the Columbia River Basin is served by the Independent Scientific Advisory Board (ISAB). Unlike the ISRP that is solely under the Council's purview, the ISAB is jointly sponsored by the Council, NOAA Fisheries, and the Columbia River Basin Indian Tribes. The ISAB provides general scientific advice on recovery efforts whereas the ISRP provides scientific review of specific project proposals. (Further background on the science review groups can be found at http://www.nwcouncil.org/fw/science.htm.)

The 1996 amendment to the Northwest Power Act requires the ISRP to determine whether projects proposed for funding:

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

- Are consistent with the program.

Thus, current decision criteria for ranking projects as "fundable or not fundable" are based primarily on technical merit and do not include any specific reference to research priorities. The consideration of research priorities is left to the ISRP to reference the Fish and Wildlife Program, which does not contain research priorities at this time. Consequently, this Research Plan, by providing priorities, should allow the ISRP to better compare and evaluate projects for relevance to research priorities.

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

Beyond Technical Merit: Review for Relevance to Research Priorities

The project review process currently benefits from CBFWA's application of management criteria and from the ISRP's requirement that projects "benefit fish and wildlife." These criteria have been used to communicate the priority of projects. For example, a study may be technically sound but redundant with an ongoing project and thus not recommended for funding. In order for this plan to function as a regional Research Plan, it is imperative that the resource managers continue their primary 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.

With some exceptions, the Council and Bonneville generally have not provided enough specific direction in solicitations regarding the research questions that need to be addressed. The Council currently is on the receiving end of proposals submitted in response to solicitations that are geographic in scope. The Council does not actively seek proposals to address specific research questions. Because this draft Research Plan identifies ongoing research, research recommendations, and gaps, the opportunity exists to use RFPs, with designated budgets agreed to by Bonneville, to close the gaps. This approach would enable the ISRP review to remain primarily focused on the technical merit of proposed projects (the research, monitoring, and evaluation RFP effort for hatchery uncertainties is an example). The open solicitation approach has proved costly in terms of failing to address the knowledge gaps, frustrating project sponsors, and expending ISRP review time on proposals that neither the Council nor Bonneville would consider funding.

Workshops featuring expert panels of scientists will be used to ensure the scientific planning process by which researchable questions of appropriate scale and staging are described as precursors to more formal Requests for Proposals (RFPs). By increasing specificity in research project solicitations, the Fish and Wildlife Program can shift from a reactive mode to a proactive mode. Future RFPs should therefore be fully supported by fish and wildlife managers and include specific criteria for project sponsors to address. The ISRP, the Council, and CBFWA will consider these criteria in their reviews. Therefore, this draft plan proposes four new approaches to the implementation of research:

- First, ongoing projects containing objectives that approach, but do not squarely address a research recommendation set forth in Chapter I should be re-examined.

- Second, all knowledge gaps should be initially considered as research needs for which projects will be sought based on a sequential priority, rather than implemented concurrently.

- Third, new decision criteria for reviewing projects should be introduced for consideration by the Regional Research Partnership. These criteria would provide additional guidance to implement the research priorities identified in this plan.

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

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

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

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

Methods of Project Selection

This section describes how projects have been reviewed and selected in the past, and might be in the future. Many implementation projects are conducted that contribute to resolving critical uncertainties. Thus, they may have a research component, but the overall project is not a dedicated research project. Please note that this prior experience will inform, but not dictate, the future project selection process, which is being developed for FY 06.

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

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

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

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

Innovative Project Reviews - The Innovative Project category was suggested by the ISRP in past annual program reviews and was designed to improve knowledge, encourage creative thinking, and provide an opportunity for project sponsors to test new methods and technologies. Innovative projects were funded in Fiscal Years 1998, 2000, 2001, and 2002. Although, innovative project solicitations were not pursued in Fiscal Years 2003 through 2005, Council members have expressed continued support for an innovative process. The Council staff recognizes the value in funding innovative projects and believes that the Fish and Wildlife Program's Research Plan will provide greater focus to future funding of innovative projects. Given the intractability of some research challenges it is important to keep the spark of innovation alive. Innovation is a critical element of any large management program or research program and should be encouraged.

By providing a platform for innovation, the Council can support experimental research to shrink vexing uncertainties. An alternative approach would be to reconfigure this element of the program from a separate, stand alone category, to an important part of each provincial review. This would encourage creativity from the ground up, and avoid any appearance that the Council itself is defining innovation.

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

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

The future form of the project selection process has yet to be determined. Future project solicitations that occur after completion of the Research Plan may attract research proposals consistent with recommendations in the plan. However, for research recommendations for which

no proposals are forthcoming, and/or for recommendations the Council decides to implement in the interim, requests for proposals could be initiated.

Project Selection Under the Corps' Fish Program

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

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

Integrating Research Results into Council Policy and Decision-making

The integration of scientific knowledge into management decision-making is a challenging task for public officials, planners, and environmental lawmakers. This integration is central to adaptive management, a concept that provides a framework for managers to launch the implementation of policies despite uncertainty, variability, and potential risks. At the core of this approach is a deliberate plan to learn from decisions and progressively fill knowledge gaps. This way, management actions, whether successful or not, provide valuable information to improve our understanding of program effectiveness and influence future management decisions in subsequent iterations of the research cycle.

Reporting Research Results

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

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

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

Data Management

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

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

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

- The project must have measurable, quantitative biological objectives.

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

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

- The project must 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.

Evaluating Research Results

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

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

- Evaluation of progress toward answering the research questions in the plan;

- Highlighting research accomplishments; and,

- Updating the plan with new research questions and priorities.

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

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

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

- Expanded provincial review presentations.

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

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

Another mechanism for evaluating and re-directing the implementation of the Research Plan should be the convocation of workshops to address emerging or previously unanticipated research issues as needed. These workshops will help assess future research topics through oral presentations, reporting of results of relevant studies, and the development of scenarios for implementing research results into management actions. The workshops will promote the free flow of scientific information and provide the Council with a credible basis for funding decisions.

Applying 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 building on that described in the preceding section It will also develop a process for reviewing the research results in order to direct new research and inform on-going work to protect and restore fish and wildlife. This review of the research results must be integrated and synthesized across projects and subject areas to determine the contribution of particular results to improving overall management. A basis for the evaluation component is an agreed upon set of research tools and description of how research results will be integrated into the Program. 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, in PNAMP development, and through various ESA related processes such as PATH. Additional tools and metrics may need to be developed.

Evaluating the Council's Research Program

Chapter I of the Research Plan describes the objectives of the plan, including increased accountability of research fund expenditures, improved coordination, etc. This section of the plan describes the evaluation component; i.e., whether these objectives are being met, and how research results will be institutionalized with the overall Program.

Adaptive Management

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

> *Adaptive management is learning by doing... Adaptive management is both a conceptual approach and a strategy for implementation. As a conceptual approach, it sets a scientifically sound course that does not make action dependent on extensive studies. As*

> *a strategy for implementation, adaptive management provides a framework within which measures can be evaluated systematically as they are carried out. Adaptive management encourages deliberate design of measures. This assures that both success and failures are detected early and interpreted properly as guidance for future action. Information from these evaluations should enable planners to estimate the effectiveness of protection and enhancement measures on a systemwide basis. Measures should be formulated as hypotheses. Measures should make an observable difference. Monitoring must be designed at the outset. Biological confirmation is the fundamental measure of effectiveness*. (Emphasis added.)

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

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

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

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

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

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

Although "adaptive management" has been the foundation underlying numerous conservation plans and strategies for restoring aquatic habitat conditions and native species, good science is still very limited in this area. Long-term commitments to science-based evaluations of management actions will be needed to address this gap. Future research efforts should be integrated, along the lines of projects supported by the NSF bio-complexity program, e.g., integrating physical, biological, economic, and social sciences, as appropriate. A stronger connection between management actions and research is a common theme that is frequently identified, but on-the-ground it is rarely implemented due to the additional costs.

One key element to an adaptive management experiment is providing a large enough perturbation to a system so a detectable change in a response variable can be measured. For example, by measuring responses to a limited range of spill and flow levels in the Columbia River hydrosystem, it will be difficult to assess detectable changes over the salmon and steelhead life-cycle and to contrast those changes in life-cycle survivals to those for transported juvenile fish. This is a key question that needs to be addressed in order to evaluate the future of

transportation, spill, and flow measures in restoring salmon, steelhead, and other aquatic populations that use the mainstem Columbia River.

We recommend that large adaptive management experiments at the scale of river sub-basins or basins be included as viable options for addressing management needs.

Balancing Curative and Preventative Approaches to Restoration

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

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

Long Term Commitment to Restoration and Recovery

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

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V. Appendixes

Appendix A. Definition of Hatchery Terms

The following definitions are derived from the *Review of Artificial Production of Anadromous and Resident Fish in the Columbia River Basin* (Council document 99-4), or from the Viability of ESUs Containing Multiple Types of Populations (2005-2).

Anadromous Fish. Individuals produced from eggs that are incubated in freshwater and that subsequently undergo a downstream migration and enter marine waters, before returning as adults from a marine migration to reproduce in freshwater. The parents could have been either resident or anadromous.

Resident Fish. Individuals that remain in freshwater and do not inhabit marine waters for a portion of their life-cycle. The parents could have been either resident or anadromous.

Natural Fish. Individuals produced from eggs that were fertilized by natural spawning and incubated instream in gravel and subsequently from fry reared in natural habitats before migration to the ocean, regardless of the culture history of the parents.

Wild populations. Fish that have maintained successful natural reproduction with little or no supplementation from hatcheries.

Hatchery Fish. Individuals produced from eggs/fry that were incubated/reared in a fish hatchery before release to complete their life-cycle under natural conditions, regardless of the culture history of the parents.

Hatchery Program. The APRE defines a *hatchery program* as production of a "like" group of fish which spends some portion of its life cycle in a hatchery environment and is released at a location within a subbasin or along the mainstem Columbia River. A hatchery program was identified by species, stock, and release location. A hatchery facility may contribute to several hatchery programs and a hatchery program may involve more than one hatchery for different rearing phases.

A group of fish delineated by the fishery managers on the basis of management purpose is termed a *stock.* Because of the management implications in this definition, fish are often divided into hatchery and natural stocks.

Population. A *population* is a group of fish delineated on the basis of genetic affinity. A population may include both hatchery and natural components if the fish are believed to represent a common evolutionary legacy and have a close genetic relationship. A group of related populations is termed an Evolutionarily Significant Unit (ESU) under Endangered Species Act (Waples 1995). An ESU is a legal and management notion that draw on the scientific concept of a *metapopulation*, which is a group of local breeding populations which are genetically connected by patterns of migration and straying and which occupy distinct habitat patches.

Appendix B. List of Reviewers of the Columbia River Basin Research Plan

Alaska resource and Economic Development, Inc. (consulting firm, Wrangell, Alaska)
Columbia Basin Fish and Wildlife Authority
Columbia River Inter-Tribal Fish Commission
Confederated Tribes of the Umatilla Indian Reservation
Oregon State University, Institute for Natural Resources
Economic Development Council, Clatsop County
ESSA Technologies Limited (consulting firm Vancouver, British Columbia, Canada)
Federal Caucus
Lathim, Mr. Del (citizen, Pasco Washington)
Lower Columbia River Estuary Partnership
Montana Department of Fish, Wildlife, and Parks
Natural Solutions (consulting firm, Helena MT.)
Northwest Fisheries Science Center, NOAA
Oregon Department of Environmental Quality
Oregon Department of Fish and Wildlife
Pacific States Marine Fisheries Commission
Taylor, Mr. Bernie (citizen, Newberg, Oregon)
Tinsley, Mr. Thomas (citizen, Springfield, Oregon)
University of Notre Dame, Department of Biological Sciences
US Bureau of Reclamation
US Department of Energy, Bonneville Power Administration
US Fish and Wildlife Service
US Forest Service
US Environmental Protection Agency
US Geological Survey
Washington Department of Fish and Wildlife
Washington Department of Ecology
Wyoming Game and Fish Department

Appendix C. Current Research Projects Under the Fish and Wildlife Program

Project Number	Project Title	Sponsor
BM2002199202604	Investigate Life History of Spring Chinook Salmon and Summer Steelhead in the Grande Ronde River Basin and Monitor Salmonid Populations and Habitat	Oregon Department of Fish and Wildl
BM2002199608300	CTUIR Grande Ronde Subbasin Restoration	Confederated Tribes Umatilla Indian
BM2002199701501	Imnaha Smolt Survival and Smolt to Adult Return Rate Quantification	Nez Perce Tribe Department of Fishe Resources Management
BM2002199801003	Spawning distribution of Snake River fall Chinook salmon	U.S. Fish and Wildlife Service
BM2002199801004	Monitor and Evaluate Yearling Snake River Fall Chinook Released Upstream Of Lower Granite Dam	Nez Perce Tribe
CG2001000021009	Assess current and potential salmonid production in Rattlesnake Creek associated with restoration efforts	U.S. Geological Survey, Underwood Conservation District, Yakama Nation
CP2002000025010	Regional Stream Conditions and Stressor Evaluation	Oregon Department of Environmenta
CP2002000025055	Echo Meadows Artificial Recharge Extended Groundwater and Surface Water Modeling	Pacific Northwest National Laboratory
CP2002000025069	John Day Salmonid Recovery Monitoring Program	Confederated Tribes of the Warm Sp Reservation of Oregon
CP2002198402100	Protect and Enhance Anadromous Fish Habitat in The John Day Subbasin	Oregon Department of Fish and Wildl
CP2002198506200	Passage Improvement Evaluation	Pacific Northwest National Laboratory
CP2002199000501	Umatilla Basin Natural Production Monitoring and Evaluation Project	Confederated Tribes of the Umatilla I Reservation
CP2002199102900	Understanding the effects of summer flow augmentation on the migratory behavior and survival of fall Chinook salmon migrating through L. Granite Res.	U.S. Fish and Wildlife Service; U.S. G Survey
CP2002199404200	Trout Creek Habitat Restoration Project	Oregon Department of Fish and Wildl
CP2002199406900	Estimate production potential of fall Chinook salmon in the Hanford Reach of the Columbia River.	Pacific Northwest National Laboratory
CP2002199705300	Toppenish-Simcoe Instream Flow Restoration and Assessment	Yakama Nation Fisheries Program
CP2002199801600	Monitor Natural Escapement & Productivity of John Day Basin Spring Chinook	Oregon Department of Fish and Wildl
HP2001000023074	Lower Columbia River and Estuary Habitat Assessment and Mapping Project	Lower Columbia River Estuary Progra
IN2001000022050	Habitat Diversity in Alluvial Rivers	Confederated Tribes of the Umatilla I Reservation
IS2003199800200	Snake River Native Salmonid Assessment	Idaho Department of Fish and Game, Idaho Office of Species Conservation
MC2002000024009	Assess Feasibility of Enhancing White Sturgeon Spawning Substrate Habitat, Kootenai R., Idaho	Kootenai Tribe of Idaho
MS2002199102800	Monitoring smolt migrations of wild Snake River sp/sum Chinook salmon	National Marine Fisheries Service
MS2002199107100	Snake River Sockeye Salmon Habitat and Limnological Research	Shoshone-Bannock Tribes

MS2002199107300	Idaho Natural Production Monitoring and Evaluation	Idaho Department of Fish and Game
MS2002199303501	Enhance Fish, Riparian, and Wildlife Habitat Within the Red River Watershed	Idaho County Soil and Water Conser District
MS2002199405000	Salmon River Habitat Enhancement M & E	Shoshone-Bannock Tribes
WP2001199001800	Evaluate Rainbow Trout/Habitat Improvements Of Tribs. To Lake Roosevelt	Confederated Tribes of the Colville In Reservation
LC2003199306000	Select Area Fishery Evaluation Project	Wash. Dept. of Fish & Wildlife, Orego Fish & Wildlife, and Clatsop County E Development Council
WP2001199404300	Monitor, Evaluate, Research and Model the Lake Roosevelt Fishery	Spokane Tribe of Indians
BM2002000027002	Assess Salmonids in the Asotin Creek Watershed	Washington Department of Fish & Wi
BM2002199700900	Evaluate Potential Means of Rebuilding Sturgeon Populations in the Snake River Between Lower Granite and Hells Canyon Dams	Nez Perce Tribe
BM2002199800702	Grande Ronde Supplementation: Lostine River O&M and M&E	Nez Perce Tribe
BM2002199800703	Facility O&M And Program M&E For Grande Ronde Spring Chinook Salmon and Summer Steelhead	Confederated Tribes of the Umatilla I Reservation
BM2002199800704	Northeast Oregon Hatcheries Implementation (ODFW)	Oregon Department of Fish and Wildl
BM2002199801001	Grande Ronde Basin Spring Chinook Captive Broodstock Program	Oregon Department of Fish and Wildl
BM2002199801006	Captive Broodstock Artificial Propagation	Nez Perce Tribe Department of Fisheries Resources Management
CC2003199604000	Evaluate The Feasibility And Risks Of Coho Reintroduction In Mid-Columbia	Yakama Nation
CG2001199506325	Yakima/Klickitat Fisheries Project Monitoring And Evaluation (Klickitat Only)	Yakama Nation
CG2001199902400	Bull trout population assessment in the Columbia River Gorge, WA.	Washington Department of Fish & Wi
CP2002000025007	Determine lamprey species composition, larval distribution and adult abundance in the Deschutes Subbasin	Confederated Tribes of Warm Spring Reservation, Oregon
CP2002000025059	Develop Progeny Marker for Salmonids to Evaluate Supplementation	Confederated Tribes of the Umatilla I Reservation - DNR Fisheries
CP2002000025062	Growth Rate Modulation in Spring Chinook Salmon Supplementation	National Marine Fisheries Service, N
CP2002000025093	Characterize Genetic Differences and Distribution of Freshwater Mussels	Confederated Tribes of the Umatilla I Reservation
CP2002198902401	Evaluate Juvenile Salmonid Outmigration and Survival in the Lower Umatilla River Basin	Oregon Department of Fish and Wildl
CP2002199000500	Umatilla Fish Hatchery Monitoring and Evaluation	Oregon Department of Fish and Wildl
CP2002199402600	Pacific Lamprey Research and Restoration	Confederated Tribes of the Umatilla I Reservation
CP2002199506325	Yakima/Klickitat Fisheries Project Monitoring And Evaluation	Yakama Nation
CP2002199802000	Assess Fish Habitat and Salmonids in the Walla Walla Watershed in Washington	Washington Department of Fish & Wi
CP2002200001900	Tucannon River Spring Chinook Captive Broodstock Program	Washington Department of Fish & Wi
IM2001000021008	Evaluation of the Banks Lake Fishery	Washington Department of Fish & Wi

IM2001000021029	A cooperative approach to identifying the role of forage quality in affecting physical condition….of mule deer in north central Washington.	Washington Department of Fish & Wi
IM2001199502700	Develop and Implement Recovery Plan for Depressed Lake Roosevelt White Sturgeon Populations.	Spokane Tribe of Indians-Departmen Resources
IS2003199405400	Tools for Managing Bull Trout Populations Influenced by Nonnative Brook Trout Invasions	Oregon Department of Fish and Wildl
IS2003199701900	Evaluate The Life History of Native Salmonids In The Malheur Basin	Burns Paiute Tribe - Natural Resourc Department
LC2003200001200	Evaluate factors limiting Columbia River gorge chum salmon populations.	U.S. Fish and Wildlife Service
LC2003200001400	Evaluate habitat use and population dynamics of lampreys in Cedar Creek	U. S. Fish and Wildlife Service
MC2002000024019	Research, Monitor, and Restore Native Species	Confederated Salish & Kootenai Tribe
MC2002198806400	Kootenai River White Sturgeon Studies and Conservation Aquaculture	Kootenai Tribe of Idaho
MC2002198806500	Kootenai River Fisheries Recovery Investigations	Idaho Department of Fish and Game
MC2002199004400	Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation	Coeur d'Alene Tribe
MC2002199404700	Lake Pend Oreille Fishery Recovery Project	Idaho Department of Fish and Game
MC2002199404900	Improving the Kootenai River Ecosystem	Kootenai Tribe of Idaho
MC2002199500400	Mitigation for the Construction and Operation of Libby Dam	Montana Department of Fish, Wildlife
MC2002199700400	Resident Fish Stock Status Above Chief Joseph and Grand Coulee Dams	Kalispel Tribe of Indians
MC2002200000400	Monitor and protect bull trout for Koocanusa Reservoir.	BC Environment
MS2002000028061	Safety-Net Artificial Propagation Program (SNAPP)	Idaho Department of Fish and Game, Tribe, Columbia River Intertribal Fish Commission, Washington Departmen and Game, Shoshone-Bannock Tribe
MS2002198335003	Nez Perce Tribal Hatchery Monitoring And Evaluation	Nez Perce Tribe Department of Fishe Resources Management
MS2002198709900	Dworshak Dam Impacts Assessment and Fisheries Investigation	Idaho Department of Fish and Game
MS2002198909800	Idaho Supplementation Studies	Idaho Department of Fish and Game Office of Species Conservation
MS2002198909801	Evaluate Supplementation Studies in Idaho Rivers (ISS)	U.S. Fish and Wildlife Service - Idaho Resource Office
MS2002198909802	Evaluate Salmon Supplementation Studies in Idaho Rivers- Nez Perce Tribe	Nez Perce Tribe
MS2002198909803	Salmon Supplementation Studies in Idaho- Shoshone-Bannock Tribes	Shoshone-Bannock Tribes
MS2002199005500	Steelhead Supplementation Studies in Idaho Rivers	Idaho Department of Fish and Game Office of Species Conservation
MS2002199107200	Redfish Lake Sockeye Salmon Captive Broodstock Program	Idaho Department of Fish and Game Office of Species Conservation
MS2002199204000	Redfish Lake Sockeye Salmon Captive Broodstock Rearing and Research	National Marine Fisheries Service
MS2002199604300	Johnson Creek Artificial Propagation Enhancement Project	Nez Perce Tribe

MS2002199700100	Captive Rearing Project for Salmon River Chinook Salmon	Idaho Department of Fish and Game Office of Species Conservation
MS2002199703000	Chinook Salmon Adult Abundance Monitoring	Nez Perce Tribe/Pacific Northwest Na Laboratory
MS2002199902000	Analyze the Persistence and Spatial Dynamics of Snake River Chinook Salmon	USDA Forest Service- Rocky Mounta Research Station
MS2002200002800	Evaluate Status of Pacific Lamprey in the Clearwater River Drainage, Idaho	Idaho Department of Fish and Game Office of Species Conservation
CP2002000025053	Evaluate bull trout movements in the Tucannon and Lower Snake rivers	U.S. Fish and Wildlife Service - Idaho Resource Office
CP2002000025049	Numerically Simulating the Hydrodynamic and Water Quality Environment for Migrating Salmon in the Lower Snake River	Pacific Northwest National Laboratory
MS2002000028001	Evaluate Factors Influencing Bias and Precision of Chinook Salmon Redd Counts	USDA Forest Service- Rocky Mounta Research Station
CE2003199801400	Survival and Growth of Juvenile Salmonids in the Columbia River Plume	National Marine Fisheries Service
MC2002000024001	Lake Pend Oreille Predation Research	Idaho Fish and Game