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COLUMBIA BASIN FISH & WILDLIFE AUTHORITY

November 30, 2004

Mark Walker
Director of Public Affairs
Northwest Power and Conservation Council
851 S.W. 6th Avenue, Suite 1100
Portland, Oregon 97204-1348

Dear Mr. Walker:

The Columbia Basin Fish and Wildlife Authority (CBFWA) appreciates the opportunity to review the *Draft Columbia River Basin Research Plan* (Research Plan) and your willingness to extend the public review period to November 30, 2004.

The governors of Idaho, Montana, Oregon, and Washington stated in their "*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*" that "… the Council, working closely with the states, federal agencies, and Tribes should develop…a draft systemwide research plan…" Subsequently, the Northwest Power and Conservation Council (NPCC) proposed in the Research Plan that "this research plan will direct research activity in support of anadromous and resident fish and wildlife in the Columbia River Basin."

The CBFWA disagrees with the NPCC assertion in the current draft of the Research Plan that "The research recommendations and critical uncertainties identified ….are sufficient to guide implementation of the research plan…" The Research Plan's general framework is not adequate, nor are many of the other sections complete. The "*Critical Uncertainties*, "*Research Recommendations*", "*Overviews*" and "*Management Needs*" sections do not sufficiently represent a comprehensive systemwide set of issues and recommendations that can be used to direct research activity in support of anadromous fish, resident fish, and wildlife in the Columbia River Basin.

The development of a research plan that is inclusive of all segments (i.e., resident fish, anadromous fish, and wildlife) of the Columbia River Basin Fish and Wildlife Program (Program) requires the participation of representatives with expertise in these disciplines. The Research Plan's lack of pertinent specific information reflects that the document was developed with little input from or collaboration with federal, state, and tribal entities. We encourage the NPCC, in the process of finalizing the Research Plan for release and public comment, to involve the basin's fish and wildlife managers for identifying critical uncertainties and research recommendations.

Listed below are general issues that the CBFWA has preliminarily identified as needing attention. The following list, as well as the attached documents, should not be considered exhaustive but instead a collection of topics that must be addressed to ensure the Research Plan is a comprehensive, systemwide research plan that represents all aspects of the Program.

- The Research Plan lacks overall context to contribute to Program implementation. It should include methods to compare the magnitude of uncertainties across subject areas and a hierarchical

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approach for decision making. A consistent level of detail across anadromous fish, resident fish and wildlife would facilitate plan implementation on a regional scale.

- The Research Plan lacks alignment between management needs, critical uncertainties, and research recommendations and thus is not a comprehensive plan. The plan should embody a consistent approach for identifying critical uncertainties and should equitably represent anadromous fish, resident fish and wildlife issues to be comprehensive. All basin research opportunities/activities are not captured in the Research Plan; specifically research activities of non-federal operators are not identified. Regional coordination needs would be better met through consistent approaches and the inclusion of all basin research opportunities.

- The Research Plan should include an evaluation component for final conclusions that is based on best available science. 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. The evaluation component should also describe how research results will be institutionalized with the overall Program. These steps could be facilitated by including pertinent literature (e.g., USFWS's Recovery Plans and subbasin plans) and describing sources for management needs, critical uncertainties, and research recommendations.

On November 22-23, 2004, the CBFWA initiated discussions with NPCC staff to address the deficiencies of the Research Plan and develop a more comprehensive document. Due to the quantity of information that was excluded from the Research Plan, the CBFWA emphasizes that it is unrealistic to expect the shortcomings of the document to be resolved during the public review period. During the November 22-23 meeting, NPCC staff expressed an interest to schedule additional meetings with the CBFWA to further develop the Research Plan.

The CBFWA is encouraged by the NPCC staff's willingness to collaborate with the fish and wildlife managers in an attempt to develop a comprehensive research plan. Unfortunately, the timeline proposed for the development and subsequent adoption of the Research Plan is problematic. The CBFWA recommends that the NPCC extend the various deadlines associated with the Research Plan, as necessary, to provide the NPCC staff, and fish and wildlife managers an opportunity to collaboratively develop a systemwide research plan as envisioned by the governors of Washington, Idaho, Montana, and Oregon. The CBFWA is willing to work with the NPCC to develop a schedule for further consultations on and revision of the Research Plan.

Sincerely,

Gary Aitken, Sr., Co-Chairman
Columbia Basin Fish & Wildlife Authority

cc: Steve Waste, NPCC
NPCC Members and Staff
CBFWA Members and F&W Managers

Attachments 3

Northwest Power and Conservation Council's "Draft Columbia River Basin Research Plan" – CBFWA Resident Fish Committee Comments

General Comments

For a research plan to be useful in a basin as complex as the Columbia River, it must be linked to performance standards and must include two elements critical for success. First, the research plan must be part of a decision analysis. Second, the research plan must be developed and implemented collaboratively by federal, state, and tribal entities, and rely on independent scientific review for quality control.

The decision analysis framework for a research plan should include the following:

1. Descriptions of the decisions that must be made relative to performance in the short, mid, and long terms, including the performance standards upon which those decisions will be based
2. A list of who will make each of the decisions
3. Descriptions of the information upon which those decisions will be based, including performance measures
4. Descriptions of how information will be collected, including who, where, and when
5. Descriptions of how information will be processed and used by decision makers, including how uncertainty and error in the information will be incorporated in decision making

Decision analysis guides research investments and focuses efforts on critical uncertainties by incorporating uncertainty and error in the data into decision making as sets of hypotheses that form the basis of research, instead of using uncertainty as an excuse for no action. It explicitly accounts for the strengths and weaknesses in research tools by using a weight of evidence approach to assigning risks to decision making due to uncertainty and error. It builds on ongoing research projects and balances research with on-the-ground actions by supporting an experimental management approach to implementing survival and recovery measures. Management actions are designed and implemented to maximize learning, while pursuing significant improvement in the status of listed fish and their environment. This approach builds research into "on-the-ground" actions and departs from the traditional approach of holding actions "hostage" to information gathering.

The research plan proposed by the Council must be developed collaboratively with the fish and wildlife managers in the Columbia River Basin. As sovereign co-managers of listed fish and their environments, the states and tribes should not be relegated to peer reviewer status. This ensures that the broad scientific expertise and perspectives of the region are taken into account when defining and measuring success.

The present research plan is not clear on the distinction between research and monitoring and evaluation; where does research stop and monitoring and evaluation begin? The difference 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 really constitute research on a larger scale and may require long-term monitoring. It would be advantageous to include text to clarify the difference between research and monitoring and evaluation, as used in the draft, near the beginning of the document.

Although the document states on page 16 that "research is not the same as monitoring", most of the Council's monitoring recommendations could just as easily fall under one of the other sections in Chapter 1 (e.g., hatchery related monitoring questions seem to fall under hatchery research questions).

Currently, the Research Plan does not adequately and equitably address resident fish research needs. The following examples provide possible approaches to resolve the existing deficiency:

1. Provide narratives for resident fish that are comparable to those that have been presented for anadromous fish. Narratives should include information contained in documents such as recovery, management, and subbasin plans.

2. Delete the specific references to “salmonids” and “anadromous fish” and replace with “fish” where appropriate and feasible. By generalizing the narratives, the Research Plan would better serve all aspects of the Columbia River Basin Fish and Wildlife Program.

Section-Specific Comments
The following comments apply to specific sections of the document. Most of these comments are general and should not be considered as a final set of comprehensive comments/recommendations. Instead, these ideas should serve as a source of initial guidance for future discussions and work sessions with the Northwest Power and Conservation Council prior to the completion of this research plan.

Profile of Current Council Research Projects and Budget
The NPCC states that “the most important factor in this analysis was consistency, so all the Council’s projects were evaluated by one staffer.” The disadvantage of this type of non-collaborative approach is evident in the summary of existing research topics. One example of work meeting the given definition of research (page 3) but not counted as such includes the evaluation of the relationship between spring flow and white sturgeon spawning success in the lower Columbia and Snake rivers (part of Project 198605000).

Critical Uncertainties and Research Recommendations for the Columbia River Basin
The document fails to identify who (i.e., what state, tribe or federal entity) identified these issues as critical unknowns or where they were described (e.g., recovery plans, state and tribal management plans, etc.). References to the corresponding entities and documents is essential and must be included. The same deficiencies apply to the “Management Needs” sections. The management needs have not been linked to any

specific management agency in the basin. It is interesting that the NPCC is identifying the management needs for the state, tribal, and federal entities.

Hatchery Effectiveness
During 2003, approximately $4.2 million was spent on resident fish artificial propagation; however, research recommendations pertaining to resident and the effects of supplementation were omitted.

Hydrosystem
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. A top priority for the plan should be to first identify and correct the problems that have been created by the hydrosystem.

The following are a few, but not all, of the critical uncertainies that exist for resident fish in the Columbia River Basin relative to the hydrosystem

Critical uncertainty

- What benefits and risks exist relative to the reconnection of resident fish isolated populations that have been artificially isolated or the supplementation of populations with individuals from previously connected populations?
- Consequences of impounding large lake systems (e.g., Lake Pend Oreille) in terms of productivity, shoreline stability, fishery impacts, and resident fish habitat needs.

Recommendations

- Determine the feasibility of restoring metapopulation connectivity by physically removing resident fish from one isolated population to another
- Determine the effects of changing lake levels at various times of the year to mitigate hydropower impacts

Habitat

- It will be difficult to "quantify" the effects of specific on-the-ground restoration and protection measures with any certainty.

- A comprehensive life-cycle approach that addresses natural variability and human impacts must be defined.

- Many research recommendations are not actually research. Recommendation 3.14, "Enhance the abundance and productivity of white sturgeon in the mainstem" is one such recommendation.

- Resident fish are likely to receive the greatest benefit from habitat actions, yet are not the focus of many recommendations.

- Recommendation 3.13 addresses spawning habitat for fall Chinook core populations, but there are no similar recommendations for other species. Of special note is the lack of a similar recommendation for chum salmon in the lower Columbia.

- Some recommendations are very specific, whereas others are very broad. The plan would be better served if the level of recommendations remained consistent at the "strategy level", rather than aiming for specific actions.

Critical uncertainties

- Impacts water release and reservoir levels have on resident fish species.

Management Needs

- Identify and corrent the impacts of hydrosystem induced lake level changes on shoreline spawning habitat on natural lakes that have been impounded.

Habitat Recommendations

- Determine what impact water release and reservoir levels have on prey species and resident fish.

- Continue to determine how dam operations affect shoreline spawning, and near-shore productivity in natural lakes that have been impounded.

- 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 warmwater fish, enhance near-shore productivity, and prevent shoreline erosion.

Recovery Planning

The objectives/actions listed below are modified excerpts from the USFWS's BiOp, and Recovery Plans for bull trout and Kootenai River white sturgeon. These items represent needs that are associated with the Federal Hydropower system. The RFC recognizes that several of the items listed below likely belong in other categories and subsequently believe that discussion regarding their appropriate designations would occur during work sessions with the NPCC.

Kootenai River White Sturgeon Research and Monitoring Needs

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

- Continue to research and develop a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture

program will include protocols on broodstock collection, propagation, juvenile rearing, fish health, genetics, and stocking.

- Continue research and monitoring programs (with achievable and measurable objectives) on life history, habitat requirements for all lifestages, population status, and trends of the Kootenai River white sturgeon.

- Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats.

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

- 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.

- 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.

Columbia River Bull Trout Research and Monitoring Needs

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

- 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.

- A primary research need is a more thorough understanding of the current, and future, role that the mainstem Columbia and Snake rivers should play in the recovery of bull trout.

- As defined in the 2000 FCRPS Biological Opinion, there is a need for continued research into distribution of bull trout within the mainstem Columbia and Snake rivers. As bull trout recovery actions are implemented (e.g., 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.

- Studies should be initiated to determine the effectiveness and feasibility of using artificial propagation to aid bull trout recovery in the Columbia and Snake rivers.

- Bull trout migrate seasonally from some local populations to the mainstem Columbia and/or Snake rivers, using using mainstem habitats during a portion of their life history. It is essential to establish, with greater certainty, the current extent of bull trout distribution and seasonal use areas. To this end, the development and application of a scientifically accepted, statistically rigorous, standardized protocol for determining present distribution of bull trout is recommended.

There are a number of research needs regarding the use of the mainstem by bull trout and its importance in their life history. One such research need is data on the movement and seasonality 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. In addition, the impact of hydropower facilities on bull trout and their habitat should 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, etc.) to determine areas of overlapping use and possible interactions. Studies are also needed to determine the migration timing and pathways in and between tributaries within the FCRPS

U.S. Fish and Wildlife Service. 2000. Biological Opinion. Effects to listed species from Operations of the Federal Columbia River Power System. U.S. Fish and Wildlife Service, Region 1 (Portland, Oregon) and Region 6 (Denver, Colorado).

U.S. Fish and Wildlife Service. 1999. Recovery Plan for the White Sturgeon (Acipenser transmontanus): Kootenai River Population. U.S. Fish and Wildlife Service, Portland, Oregon. 96 pp. plus appendices.

U.S. Fish and Wildlife Service. 2002. Bull Trout (Salvelinus confluentus) Draft Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

Harvest Management

There is no mention of harvest management needs for resident fish. Critical uncertainties relative to resident fish should be included. For example, uncertainties exist at to what level resident fish can be harvested without impacting the viability and productivity of the population

Research Recommendation

- Determine harvest levels of important resident fisheries such that stocks are protected

Invasive Species

The first management need addresses the effect of invasive species on fish and wildlife of the Columbia River basin, yet the second need is limited to impacts of shad on anadromous fish. Research recommendations should also consider resident fish and wildlife.

Management Needs

- Determine the impacts of harmful exotic resident fish species on native fish assemblies.
- Determine areas of high predator abundance.
- Determine contribution of exotic predators through entrainment and connected waterways.

Research Recommendations

- Develop methods for the removal of harmful exotic fish or methods to minimize their impacts
- Determine the impact trophic impacts of exotic species

Attachment 2 11/30/04

CBFWA Resident Fish Committee Comments:
Section I. Planning for the Future, Taking Stock of the Present

Draft Columbia River Basin Research Plan

By the

Northwest Power and Conservation Council

October 2004

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

Background

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

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

A Research Plan for the Columbia River Basin

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

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

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

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

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

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

Relationship to Existing Research Plans in the Columbia River Basin

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

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

Profile of Current Council Research Projects and Budget

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Critical Uncertainties and Research Recommendations for the Columbia River Basin

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

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

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

Hatchery Effectiveness

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Critical Uncertainties: Uncertainties exist regarding the potential for both benefits and harm to the naturally spawning populations. A major uncertainty is whether it is possible to integrate natural and artificial production systems in the same basin to achieve sustainable long-term productivity. Some scientists and managers believe that it is likely that supplementation will produce an increased abundance of natural-origin ~~salmon~~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 ~~of salmon and steelhead~~ have not been determined empirically and these knowledge gaps need to be filled.

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

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

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

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

1.1 Determine the effects of wild-hatchery fish interactions and the impacts of hatchery management programs on wild stocks.
1.2 Test the assumptions about survival differences between hatchery and wild fish.
1.3 Determine the origin and the temporal and spatial distribution of wild ocean-caught fish.
1.4 Determine the long-term persistence of natural elemental signatures in fish scales.
1.5 Improve the persistence of cold marks at the focus of otoliths in swim up fry to allow for subsequent detection. Although lethal otolith sampling is required to detect marks, this technique may still serve a useful purpose for certain research applications.
1.6 Assess the effectiveness of batch marking of fish scales using applied concentrations of microelements. Micro-elemental marking of fish scales and otoliths may be an alternative to cold marking techniques in hatchery research.
1.7 Determine the exact timing of imprinting in juvenile ~~WCT~~westslope cutthroat trout and b~~B~~ull trout. Assured imprinting on a specific water source will reduce the potential for straying when fish are planted to establish a new wild spawning run.

Hydrosystem

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

establish priorities for the tasks included in this work plan. This will help focus the Council's resources and advise other agencies on those tasks that offer the most immediate benefits and are likely to be the most important to achieving the Council's vision for the basin.

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

Management Needs:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The Council's Research Recommendations:

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

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

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

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

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

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

2.7 Implement an experimental operation at Hungry Horse that will limit the summer draft to 10

	feet from full pool by the end of September.
2.8	Determine the feasibility and implement research as necessary to evaluate the biological effects of flow augmentation from Libby and Hungry Horse on salmon survival in the Lower Columbia River. Design and implement new survival tests in the lower river to better understand the movement and survival of fall Chinook.
2.9	Continue to evaluate turbine passage to determine the optimum fish survival through turbines. Continue the research and design work on improved turbines and the relationship between survivals and overall turbine operating efficiencies.
2.10	Modify turbine designs to improve juvenile salmon passage survival. Evaluate alternative designs and implement as soon as possible in those dams where they would provide the greatest biological benefits.
2.11	Continue to evaluate survival benefits of transport from McNary Dam to determine whether the survival benefits of transport from McNary are sufficiently greater, at least under certain circumstances, than inriver passage to justify continuing (or increasing) the transport effort from that dam.
2.12	Conduct a transportation study targeting Snake River fall Chinook. Evaluate relative success of transporting various groups of fish throughout the Snake River.
2.13	Determine the differential delayed mortality "D" effects due to transport.
2.14	Investigate and implement actions to reduce toxic contaminants from entering the Snake and Columbia rivers.
2.15	Review operational procedures to identify efforts that could be taken to avoid exceeding total dissolved gas saturation limits of 120 percent, over a time period of the twelve highest hourly measurements at all Federal Columbia River Power System projects engaged in spill operations.
2.16	Determine the feasibility and perform as necessary the research to determine the survival benefits of lowering total dissolved gas levels from the waiver amount of 120 percent to the Total Maximum Daily Load of 110 percent.
2.17	Determine the effects of predation on salmonid recovery and how predation is affected by other environmental factors.
2.18	Evaluate the impact of predation on fish survival and smolt-to-adult return rates.
2.19	Determine the factors influencing predation rates on salmonid smolts in the Columbia River estuary.
2.20	Continue to improve estimates of the impacts of seabird predators on wild salmonids.
2.21	Improve the estimates of the impact of pinniped predation on salmonid stocks and on the recovery of depressed stocks.
2.22	Conduct an integrated operational loss assessment of ecological impacts to fish and wildlife resources.

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Habitat

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

~~populations and provided high-quality rearing habitats for maturing and migrating juveniles, has been destroyed by reservoir inundation, degraded by altered flows from hydropower, flood control, and irrigation, or disconnected from the salmon ecosystem by dams that block migratory pathways.~~

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

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

Management Needs:

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

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

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

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

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

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

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

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

10. Identify current and critical habitat needs in the mainstem of the Columbia and Snake rivers and seek to increase the extent, diversity, complexity and productivity of mainstem habitat by protecting, enhancing and/or connecting mainstem spawning, rearing and resting areas.

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

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

The Council's Research Recommendations:

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

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

3.3 Conduct an integrated assessment of the role of primary and secondary production~~food and feeding on the nutrition of downstream migrants~~ leading to conclusions regarding action options for restoration of riverine food chains such as induced flooding, hydro operations and riparian habitat restoration) and promotion of ecologically based ~~estuarine~~ food

webschains, for example species stocking.

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

3.5 Estimate, through field studies of insect colonization and growth during flooding and spatial analyses of floodplains, the quantity of salmonid food potentially produced by flooded riparian lands in the lower Columbia-Snake basins and lost by river regulation, and relate quantitatively to the food requirements of migrating juvenile salmon.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.23 Determine the effects of livestock browsing on aspen sprouts.

3.24 Conduct an integrated assessment of operational losses in the Columbia River Basin to

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promote an ecological based restoration program.

Recovery Planning

Overview: Fish and wildlife species~~Different species~~ and populations ~~of salmonids in the Columbia~~are characterized by ~~River and elsewhere exhibit remarkable~~ life history, ecological, behavioral, phenotypic, and genetic diversity. ~~This diversity is a hallmark of salmonids in general and arose from differential or local adaptation to the varied and variable environments within the complex landscapes of the Pacific Northwest.~~ Such diversity buffers fish and wildlife~~salmonid~~ populations against short- and long-term environmental variation and has become even more important today as human activities have increased the rate and amplitude of environmental fluctuations over those that occurred historically.

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

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

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

Management Needs:

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

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

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

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

The Council's Research Recommendations:

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

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

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

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

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

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

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

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

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

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

4.11 Determine effectiveness and feasibility of using artificial propagation in bull trout recovery.
4.12 Identify status, limiting factors, and management alternatives for lamprey.
4.13 Determine capacity of each potential local bull trout population.

Monitoring and Evaluation

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

O**verview:** Understanding the effect of habitat conditions on anadromous and resident fish and wildlife population performance requires replicated observational studies or intensive research level experiments to be conducted at large spatial and long temporal scales. Few evaluations of tributary habitat in the Columbia Basin meet these criteria. The expense and effort needed to obtain the data necessary for evaluating the response of ~~salmonids~~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 collaborative research effort. By implementing these evaluations with clear objectives, careful employment of experimental and statistical design, disciplined adherence to the experimental constraints in treatment and reference sites, and patience, results can be obtained that will greatly improve the ability to ensure viable fish and wildlife populations.

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

Management Needs:
1. Monitor and evaluate the effectiveness of habitat improvement projects.

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

The Council's Research Recommendations:

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

5.2 Develop and implement a long-term statistical monitoring program (Tier 2) to evaluate the status of fish and wildlife populations and habitat. This action would entail development of probabilistic (statistical) site selection procedures and establishment of common protocols for cost-effective "on the ground" or remotely sensed data collection of a limited number of indicator variables.

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

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

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

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

5.7 Continue to determine how specific operations, flow and spill conditions affect ~~passage success of~~ adult salmonids, fish and wildlife species downstreams of ~~migrating past the mainstem~~ dams.

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

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

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

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

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

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

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

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

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

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

Harvest Management

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

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

Management Needs:

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

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

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

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

Critical Uncertainties:

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

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

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

The Council's Research Recommendations:

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

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

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

6.4 Evaluate appropriateness of stocks used in weak stock management.

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

Estuary

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

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

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

Characterization of the estuary's physical and biological attributes that support salmon is underway, but is in its infancy. The draft NMFS report, *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon*, assessed the potential impact of flow regulation on juvenile salmon utilization of the estuary. The report found that hydrologic and climate factors likely have consequences for the estuarine physical environment. However with the existing data it is not possible to separate these effects from compounding factors or to rank these factors' effects on salmon. Yet, it is clear that changes in the food web have occurred that affect the estuary's capacity to support juvenile salmon and that have reduced habitat complexity.

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

Management Needs:

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

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

Critical Uncertainties:

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

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

The Council's Research Recommendations:

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

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

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

maintenance, or controlling predator populations.

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

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

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

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

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

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

7.9 Conduct research on food web dynamics.

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

7.11 Conduct research to understand juvenile and adult migration patterns.

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

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

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

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

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

Natural Variation and Ocean Productivity

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

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

by northern fisheries trying to compensate for coincidental decreases in the production of stocks from Alaska and British Columbia.

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

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

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

Management Needs:

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

Critical Uncertainties:

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

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

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

The Council's Research Recommendations:

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

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

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

Emerging Issues

Impacts of Climate Change on Fish and Wildlife Restoration

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

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

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

~~believes a more complete review is warranted of the potential impact of climate change on the freshwater environment including changes to snowpack, stream flow, and species distribution. The ISAB intends to fully undertake the freshwater component of the review after completing the harvest review. The ISAB will focus on describing the potential scale of the impacts of climate change on the success of restoration efforts and how the uncertainty of impacts could be incorporated into fish and wildlife planning and management. The review should be useful in informing future program amendments and recovery planning.~~

Management Needs:

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

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

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

Toxics

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

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Today, a major issue is the lack of a "relative risk model" to extrapolate potential contaminant risk to fish and wildlife~~salmon~~ in the majority of areas where there are few or no data.

~~(This topic will be discussed in a workshop sponsored by EPA and NOAA Fisheries and hosted by the Council in spring of 2004.) The inability make even a qualitative assessment of risk from contaminants basically anywhere in the Pacific Northwest is a major gap in our understanding that contributes to gaps in management.~~

Environmental contaminants such as trace elements (including heavy metals), pesticides, petroleum, and related petrochemical compounds pose a substantial threat to some aquatic ecosystems. Fish are vulnerable in rivers and lakes draining watersheds that support irrigated

agriculture, mining, fossil fuel power generation, large municipal/industrial complexes, and other concentrated sources of human-caused activities. Managers require contaminant surveys and bio-monitoring to detect the occurrence and bioaccumulation of suspected contaminants. Studies are also needed in aquatic eco-toxicology to detect and quantify fate and effects in the environment. Endocrine disrupters are a particularly significant issue requiring basic research, currently undertaken by the Western Fisheries Research Center of the U.S. Geologic Survey.
Chemical processes are critical determinants of habitat quality for salmonids, and they should be explicitly addressed at the outset of any restoration. ~~In Seattle, adult coho salmon have perished when they came back to spawn in small urban streams. Many millions of dollars were spent to restore "habitat" in these systems, with a near-exclusive focus on physical processes. Longfellow Creek in West Seattle is a regional model for stream restoration, and yet almost 90-percent adult pre-spawn mortality occurred in the 2002 coho run, apparently as a result of degraded water quality.~~

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

Management Needs:

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

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

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

Critical Uncertainties:

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

2. Little information exists on contaminant body burdens in hatchery fish versus wild listed stocks. Wild fish will not have the extra exposure from feed that is seen in hatchery fish, but wild fish also may remain in the estuary longer and accordingly have more potential to take up contaminants from the environment. It is known that off-channel habitats, where wild

juvenile salmon tend to be found, are the areas with comparatively higher levels of chemical contaminants in sediment and presumably prey.

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

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

The Council's Research Recommendations:

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

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

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

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

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

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

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

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

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

Invasive Species

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

~~It is important to note the distinction that exists between an invasive species and a non-native that is the result of a management decision. An example of a non-native fish species potentially~~

~~impacting anadromous stocks is American shad. In addition to shad, there are a number of other introduced and exotic species present in the Columbia River Basin Ecosystem that we know very little about. Some of these species include: channel catfish, yellow perch, bluegill/other sunfish, crappies, Eurasian milfoil, Asiatic clams (*Corbicula manilensis*), and others. All of these species have an impact on juvenile salmonids, either directly (as predators) or indirectly (by altering the food base).~~ As these species continue to become more dominant in the ecosystem they will have a greater impact on ~~salmon~~ native fish and wildlife populations~~populations~~. ~~Once established, ANS can permanently alter habitat supporting native aquatic species.~~ Research should be initiated as soon as possible to understand the significance of these impacts. Offsite projects, particularly lake rehabilitation, have been successful in removing hybridized fish populations, creating genetic reserves for native fish, drastically improving fisheries, and eliminating source populations for further illegal introductions. The Corps should be alert to regional decisions, including Council decisions, that might bear on passage or survival issues at the dams.

Management Needs:

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

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

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

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

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

The Council's Research Recommendations:

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

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

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

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

10.5 Develop rapid response methodologies to eliminate newly introduced species at the source

of introduction before they spread and become unmanageable in the environment.

10.6 Determine how presently accepted non-indigenous species (warm-water fish) can be managed to minimize ecological effects.

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

Impact of Human Development Patterns on Fish and Wildlife Restoration

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

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

Attachment 3
11/30/04

FISH PASSAGE CENTER

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MEMORANDUM

TO: FPAC

Michele DeHart

FROM: Michele DeHart

DATE: October 27, 2004

RE: Comments on NPCC Draft Columbia River Basin Research Plan

At your request the Fish Passage Center staff has prepared comments on the NPCC Draft Columbia River Research Plan (Plan). The FPC has limited its comments to the hydrosystem section of the Plan and is providing them to you in order to facilitate your meeting the short deadline for comments.

General Comments

The research recommendations on hydrosystem evaluation the Council has outlined do not seem to be supported by their own background documents. The Council lists as sources for its research recommendations in Appendix D, both Independent Scientific Groups (ISG) and State of the Science Documents. In both sections, the document that addresses hydrosystem research is the Return to the River by the Scientific Review Group (SRG). The "Return to the River" document, extensively reviews scientific literature and provides 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 comparisons between free-flowing rivers and impoundments and their differing hydraulic characteristics. The following is then offered as conclusions in the hydrosystem section...

> "...Although not easy, one could envision flow management in which reservoirs are drawn down temporarily in different ways in successive years: for example, one year in three for maximal support of constant flushing behavior, and another in which floods are created to overtop riparian zones to create maximal shoreline habitat. The third year could be maintained stable. These flow strategies could be coupled with non-flow measures for salmon

such as replacement of shoreline rock rip-rap with vegetation. The occasional exceptionally dry year (that restricts planned flooding) or wet year (that floods no matter what the plan) would add a certain primal variability."

From this concluding statement it seems that the ISG suggested 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. But the recommendations of the draft research plan seems to emphasize continuing with the AFEP process as is (i.e. using the COE funds to evaluate survival improvements dam by dam.) Outside the COE funded research, those areas identified are ways to decrease the cost of operating the hydrosystem without a clear intent to improve in-river conditions ("summer spill reductions as well as decreased in-season flows from Libby and Hungry Horse dams and finding ways to limit total dissolved gas production to below 120% via flow alterations). In other words, the Council program adopts the current research program that is ongoing as its own and otherwise seeks ways to save money on operations. The Council has been criticized by the SRG for this very problem in 1992 and again in 2002, when the ISRP stated (according to appendix B) "that the draft (research plan) essentially defined existing research as the research program." It appears that this research plan falls under the same category. There does not appear to be any overarching framework that quantifies risk at each life stage as the foundation for prioritizing research. Nor does there appear to be an adaptive management strategy that tests hypotheses related to "Return to the River" principles in order to develop a more normative passage corridor that protects life-history diversity.

Comments on Specific Language within the draft

Section entitled Management Needs (page 8):

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

We support this work, which is already being undertaken to some extent within AFEP. However, a more comprehensive look at system survival needs to be undertaken to evaluate benefits of spill, since this ties in with one critical uncertainty, which is the indirect effects of hydro-system passage. 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. With the number of RSW's being considered for installation this relationship could change and, a model of spill efficiency should change as well. Further tests should be conducted with the existing RSW's so that the region can be assured that future installations benefit fish survival.

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

This is a low priority in terms of fish survival improvements, since the likely improvement in survival is low, and since the goal is to pass less than 20% of fish through

turbines, the overall improvement in survival by improving direct turbine mortality is likely small.

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

Incremental benefits are likely to be difficult to measure with current techniques if the increments are small. However, reach survival has shown to improve with increasing flows, despite statistical difficulties of detecting such improvements, and it would only follow that incremental decreases in augmentation would lead to reductions in survival that may not be statistically detectable using reach survival estimates with present PIT-tag technology. Reductions in augmentation could not be argued to improve survival, since they would likely decrease survival. How much reduction would it take to be statistically detectable depends on the tagging technology available, and the willingness to risk entire populations to experiment.

While the fish and wildlife program related to augmentation was recently amended to include the consideration of impacts on resident populations of fish, the beneficial use protected by augmentation must be weighed. And under such an analysis, we are confident that the small incremental benefits to large populations of salmonids would outweigh benefits to localized populations of resident species.

Section entitled Critical Uncertainties (page 8):

...The present flow management strategy does not take into account the complex migratory behaviors of juvenile salmonids...

We agree that this is an important uncertainty. In the context of the "Return to the River" document, this statement would mean that attempts should be made to mimic natural hydrograph and natural river morphology and hydrodynamics. To evaluate this uncertainty, there should be an evaluation of draw-down; an evaluation of our ability to mimic the success of the Hanford Reach for producing a self-sustaining population of wild fish both in terms of spawning and rearing habitat, and as a natural migration corridor. This could be attained by drawdown of McNary and John Day pools, and drawdown or mothballing and circumventing Little Goose Dam. Little Goose Pool could provide a large section of river available for fall chinook spawning, and as a natural river provide rearing habitat for wild Snake River fall chinook migrating through that section of river.

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

We agree with these uncertainties and maintain that drawdown remains the best way to evaluate some of these options. Benefits from "*stage waves and turbulent bursts, or pulsing flows*" are likely to be highest in a drawn-down reservoir.

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

We would agree in principle with the idea of trying to achieve water quality standards in spillways. High gas levels, in the reservoirs likely affect fish survival, but not significantly, at the levels identified here. Higher gas levels are unrelated to passage measures. We believe the monitoring and evaluation to date, suggest that TDGS above 125% at tailwater monitors would likely be detrimental to migrant salmonids, with greater impacts likely to resident fish at lower gas levels. Research in reservoirs does not suggest that the incidence of signs of GBT are greater than those seen at the dams via monitoring. Further, studies suggest that fish move up and down in the water column thereby limiting effects of high TDGS. These issues would be worth considering in relation to other goals, such as trying to achieve normative hydrograph. But the costs of achieving lower TDGS levels, either in terms of further structural modifications to the dams, or by altering hydrograph to reduce spring peak flows and thereby reduce benefits of flows to juvenile migrants are probably prohibitive of improving much beyond present conditions. Assuming RSW's become the prevalent in future years, high gas levels will only occur during involuntary spill, which will only occur during very wet years.

Section entitled The Council's Research Recommendations (page 9 and 10):

2.1 – The Council recommends designing a comprehensive research program relating specific passage research at each dam with overall system survival evaluations. This is an admirable and important goal. We agree that there needs to be a comprehensive approach to research that should not be limited to specific agency realms. Although we strongly support this approach, a more detailed discussion of how this could be done is needed. The AFEP program continues to assess route specific survival at dams. However, it is imperative that the integration of passage research should be associated with overall system survival benefits in terms of survival to adults.

2.2 – We do not agree with this recommendation. Implementing a summer spill test should include the full range of ability. At this time there is no summer spill at McNary Dam and at the Snake River and spill is limited to volumes less than the gas cap volumes at other projects. Spill is also limited by date, ending on August 30 regardless of fish passage into September. An evaluation of spill should include not just a reduction of spill in summer, but also an increase in spill to all projects at full gas cap spill into September.

2.3 – We agree with this recommendation. Surface passage systems for passing larger numbers of fish via spillway weirs are an admirable goal. The region is presently embarking on this course so this is not really different that status quo. 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 survival downstream component and survival to adult component in order to determine the impact of potentially reduced spill on predator abundance and success as well as to determine if any delayed mortality can be ascribed to these passage alternatives. Another key to this recommendation is the concept of fully testing these passage systems and the 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.

2.5 - Spill passage will never be cost effective unless spill is in excess of hydraulic capacity or in excess of generation needs. At all other times it is not cost effective. That does not negate its biological effectiveness. While SBC look promising in terms of passing large numbers of fish with little water, it remains to be seen what the system wide impacts are related to this objective.

2.6, 2.7, and 2.8: It is unclear how the reduction in present mitigation would be evaluated or how it would improve survival for migrant juvenile salmonids. 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. Proposed studies must include analysis for a range of summer flows, and varying operations of Grand Coulee (1278 or 1280 draft), Albeni Falls (2051 of 2055 draft) and Canadian Projects.

2.9 –2.10 –While the recommendation for modifying turbine designs has some merit, we consider it a very low priority for funding since the survival improvements likely from this area research are minimal. And any gains in direct survival at individual projects, may be offset by decreases in reach or system survival and delayed mortality. This means costly evaluations that may have little impact. Therefore we recommend very low priority in overall system improvements.

2.11 – 2.13 – This is underway under COE's AFEP process. The transportation experiments that are on-going will address some of the Council's recommendations. The most outstanding inadequacy is how the Council refers to the Snake River fall chinook studies. There is adequate information on the transportation of Snake River fall chinook to suggest that it does not provide benefit over in-river migration routes and will not be able to achieve recovery goals for this stock. Therefore, it is imperative that any research plan immediately address the comparison of transport versus migration through the corridor with improved inriver passage via summer collector project spill programs to the spill cap. We would recommend a more aggressive summer spill program that provides greater spill in the Snake River so that a true spread-the-risk approach is tested. With a more aggressive spill program, a transport versus in-river evaluation would lead to useful conclusions. Based on recent findings, the transportation program for fall chinook in the Snake River survival is not as good as that for fish that have been bypassed, suggesting that if a greater portion of fish were spilled in the Snake the benefits of transportation would be even lower. This should be evaluated in a way that mimics the best in-river conditions possible and is implement able in 2005. With the inclusion of RSWs at Snake River dams, the

volume of spill necessary to pass larger portion of fish may decreased, but again the total effect of RSWs has not yet been addressed and this too should be further evaluated.

2.15 -2.16 – We would agree in principle with the idea of trying to achieve water quality standards in spillways. Operational procedures and project modifications have been very successful at limiting total dissolved gas to the 120% level when flow is less than hydraulic capacity. Short of removing projects, there is no way in a high flow to assure that gas does not exceed the limit. Considerable effort has already been taken to study the effects of these waiver gas levels on migrating salmonids. High gas levels, in the reservoirs likely affect fish survival, but not significantly, at the levels identified here. We believe the monitoring and evaluation to date, suggest that TDGS above 125% at tailwater monitors would likely be detrimental to migrant salmonids, with greater impacts likely to resident fish at lower gas levels. Research in reservoirs does not suggest that the incidence of signs of GBT are greater than those seen at the dams via monitoring. Further, studies suggest that fish move up and down in the water column thereby limiting the effects of high TDGS. These issues would be worth considering in relation to other goals, such as trying to achieve normative hydrograph. But the costs of achieving lower TDGS levels, either in terms of further structural modifications to the dams, or by altering hydrograph to reduce spring peak flows and thereby reduce benefits of flows to juvenile migrants are probably prohibitive of improving much beyond present conditions. Assuming RSW's become the prevalent in future years, high gas levels will only occur during involuntary or over generation spill. We believe there is little survival benefit to be gained for migrant salmonids in the Columbia River system by reducing TDGS from 120% to 110% and in the context of the original Risk Assessment, which was re-evaluated by NOAA Fisheries for the 2000 Biological Opinion, the benefit to salmon of passing via spill are in excess of the detriments encountered at these spill levels.

Section entitled Identifying Research priorities (page 40):

Given the whole breadth of critical uncertainties and questions raised elsewhere in the document it remains unclear as to why the short-term research recommendations are so selective. Three of the four short term recommendations offered in the Council's Plan propose testing reductions from the present mitigation by limiting flow augmentation from the Montana Reservoirs. This approach favors viable non-jeopardized resident populations while potentially placing listed species at further risk.

The long-term research recommendation for transportation of fall chinook should clearly include the provision of testing improved in river conditions.

Therefore, in conclusion, the Council's Research Plan for the hydrosystem continues the COE's AFEP process, but outside of this process the Plan only identifies ways to decrease the cost of operating the hydrosystem without a clear intent to improve in-river conditions and improve fish survival.