Research, Monitoring and Evaluation (RM&E) Plan For the National Marine Fisheries Service (NMFS) 2000 Federal Columbia River Power System (FCRPS) Biological Opinion

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By

The NMFS and FCRPS Action Agencies (Bonneville Power Administration, Corps of Engineers, and Bureau of Reclamation) RM&E Workgroup

Reviewed by Federal Agencies Participating Within the Federal Caucus All-H Recovery Strategy

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I. Introduction

The National Marine Fisheries Service (NMFS) and the Federal Columbia River Power System (FCRPS) Action Agencies (AA) (Bonneville Power Administration (BPA), Corps of Engineers (Corps), and Bureau of Reclamation (BOR)) are working together to develop and implement a Research, Monitoring, and Evaluation (RME) Plan that is called for under the NMFS 2000 FCRPS Biological Opinion (BiOp) and the Federal Columbia River Salmon Recovery Strategy (All-H Strategy). The resulting RME program is intended to provide information needed for assessment of Endangered Species Act (ESA) listed Columbia Basin salmon and steelhead populations at the 2005 and 2008 year NMFS BiOp check-in evaluations. In addition, this program will inform the identification and prioritization of actions that are the most effective towards improved stock performance and provide information for the 2010 NMFS Biological Opinion. Significant elements of the RME program are identified through a number of specific action items called for within the NMFS BiOp Reasonable and Prudent Alternatives (RPA). Of the 199 RPA actions listed in the BiOp, RPA actions 158-162 and 179-199 are explicit to RME.

This document defines an RME program that is currently limited to the specific requirements of the NMFS FCRPS BiOp. Additional RME requirements of the U.S. Fish and Wildlife Service FCRPS BiOp for ESA listed resident fish will be integrated with this RME program as they are developed in coordination with resident fish recovery planning. This RME program will also be integrated with the broader RME needs of the Federal All-H Strategy and the Northwest Power Planning Council's (NWPPC) Fish and Wildlife Program, in coordination with other regional Federal, state, and tribal RME programs. The AAs and NMFS are working with these other regional entities to identify areas of program overlap, coordination efficiencies and funding responsibilities. Additional discussion regarding coordination is provided in Section II - FCRPS RME Framework, Subsection F - Regional Coordination.

The NMFS FCRPS BiOp assessment and resulting RPA is based on the best available scientific information, but recognizes substantial uncertainty that must be addressed through the development and tracking of biological and physical performance standards. The BiOp identifies performance standards for population status (trends and growth rates), hydro system survival improvements, and offsite mitigation survival improvements. Additional biological and physical performance standards for hydro, hatchery, harvest, and habitat actions are being developed by June 2003. These performance standards will be checked with periodic evaluations that rely on research and monitoring of performance. Figure 9.5-2 in Section 9.5.1 of the BiOp clearly depicts the linkage between the performance standards, evaluations, and subsequent decisions. This RME Program is designed to support the evaluation process and address the uncertainties in the RPA.

The RME Program describes six principal components that must be addressed to meet the BiOp requirements: (1) Population and Environmental Status Monitoring, (2) Action Effectiveness

Research, (3) Critical Uncertainty Research, (4) Project Implementation Monitoring, (5) Data Management, and (6) Regional Coordination. These components and associated sub-components of the Program are described in Section II.

Over the past year the AA and NMFS have been working to more explicitly define the RME requirements of the BiOp, review existing and proposed research, and identify additional RME actions that are needed. This work has been completed through the following six workgroups: (1) Status Monitoring, (2) Action Effectiveness Research (for tributary habitat actions), (3) Hydro, (4) Estuary/Ocean, (5) Hatchery/Harvest, and (6) Data Management. These workgroups address different levels of the six RME components or combinations of sub-components and the associated RME BiOp RPA actions. Table XX identifies the association of these workgroups with the RME components/sub-components and RPA actions. Each workgroup is chaired by a member agency and includes designated participants from the contributing federal agencies, and technical analysts from the private sector. A Planning Group oversees and coordinates the workgroup's efforts.

Each of the work groups were asked to: (1) identify the RME requirements of the BiOp within their workgroup area; (2) identify ongoing and planned research or monitoring projects that address these RME requirements within the Corps' Anadromous Fish Evaluation Program (AFEP) forum, BOR's priority subbasin program, and the BPA funded NWPPC's Fish and Wildlife Program; (3) compare the RME requirements of the BiOp with the existing and planned research projects to identify gaps in existing coverage; and (4) recommend any necessary additional research or changes to planned research. Each work group produced an RME Plan specific to their areas of RME component coverage and related RPA actions.

The RME program requires the development of new efforts and the revision of some ongoing efforts, as well as the continuation of certain established monitoring activities. Where possible, some existing projects can alter scope and revise work statements to more closely address RME BiOp requirements. If gaps in BiOp requirements are not currently being funded or proposed for funding under the existing AA programs or through NMFS funding appropriations, a special request for proposals (RFPs) or qualifications (RFQ) may be developed.

The next sections in this planning document are organized as follows:

- Section II describes the framework and components of the FCRPS RME Program.
- Section III summarizes the individual RME plans drafted by each work group.
- Section IV contains the detailed RME Plans drafted by each work group, included as individual appendices.

II. FCRPS RME Plan Framework

The RME plan identifies six principal components and their associated sub-components that must be addressed to meet the BiOp requirements:

1. Populations and Environmental Status Monitoring – abundance, trend, and condition of fish populations and key environmental attributes.

   - Ecosystem/Landscape – broad scale, periodic monitoring (Tier 1 @ BiOp)
   - Geographic Zone – localized, frequent monitoring (Tier 2 @ BiOp)
     - Tributary Habitat
     - Hydro-corridor
     - Estuary/Ocean

2. Action Effectiveness Research (Tier 3@ BiOp) – effects of hydro and offsite mitigation actions on fish survival and habitat attributes.

   - Hydro
   - Habitat
   - Hatchery
   - Harvest

3. Critical Uncertainty Research – addresses key uncertainties in population survival assessments (e.g., "D", extra mortality, hatchery spawner reproductive success, etc.)

4. Implementation/Compliance Monitoring – tracking execution of management actions

5. Data Management – support system for data storage and access

6. Regional Coordination – across the various Federal, state, and tribal RME programs

Two of the components, Action Effectiveness Research (AER) and Critical Uncertainty Research (CUR) are distinguishable from Status Monitoring activities in that some evaluations may require formal experiments and rigorous statistical analyses. However, AER and CUR both complement and sometimes depend on status monitoring for baseline conditions. In some cases, indicators tracked for status monitoring may also apply to action effectiveness and critical uncertainties research and vice versa. However, the objectives and scope of those monitoring components differ from status monitoring in terms of spatial and temporal sampling and the required statistical framework.

Six workgroups have been formed to address the principle RME components and sub-components of the RME Program:

A. Population and Environmental Status Monitoring Workgroup
   - Status Monitoring Ecosystem/Landscape component
   - Tributary Habitat Geographic zone subcomponent

B. Action Effectiveness Research Workgroup – tributary habitat actions
- Action Effectiveness Research at the Tributary Habitat subcomponent

C. Hydro Workgroup
- Status Monitoring for the Hydro-corridor geographic zone
- Action Effectiveness Research at the Hydro action subcomponent
- Critical Uncertainty Research for extra mortality (EM) and delayed transport effects "D"

D. Estuary/Ocean Workgroup
- Status Monitoring for the Estuary/Ocean geographic zone
- Action Effectiveness Research at the Estuary/Ocean Habitat subcomponent
- Critical uncertainties that involve processes that may be manifested in the estuary/ocean due to effects that originate upstream

E. Hatchery-Harvest Workgroup
- Action Effectiveness Research as it pertains to hatchery (i.e., management) and harvest (i.e., tangle nets, etc.) actions on wild fish
- Critical Uncertainty Research with respect to reproductive success of hatchery fish spawning in the wild

F. Data Management Workgroup
- Data Management and Implementation Monitoring components

A. Status Monitoring

The need for status monitoring and corresponding performance standards was identified in the BiOp and specifically called for under RPA Action 180. The objective of status monitoring is to document progress toward the recovery of listed ESUs and condition of their associated habitat. Status monitoring tracks the condition of the populations relative to specified quantitative performance standards specified in the BiOp, or other and key environmental attributes that may be deemed as appropriate. Quantitative standards for environmental conditions are scheduled for development in the first half of 2003 through a Federal Caucus RME workgroup. For each ESU, status is evaluated at the population level and for survival during certain life stages. Information gathered through status monitoring would be used to identify and prioritize areas requiring improvement in management. The data would be important in recovery planning for ESA listed salmonids and would be useful for NWPPC subbasin planning efforts.

Performance standards provide a context for status monitoring and are goals that, if achieved, will indicate either acceptable ESU recovery and/or acceptable environmental conditions. Some BiOp performance standards apply to the overall condition or productivity of a population unit (e.g., ESU), others specify life stage survival rates, and still others remain to be specified. In the BiOp, sections 9.2.2 and 9.3.3 identify four classes of performance standards:

1. ESU population abundance, productivity, and response to actions;

2. Survival rates through the FCRPS hydro-system;

3. Collective survival increase through the life cycle attributed to offsite mitigation;

4. Standards for key Environmental/Physical attributes.

This plan identifies the performance measures, or indicators, that need to be monitored to satisfy the AA obligations under the BiOp. These may have broader application to support planning and adaptive management as identified in the AA Implementation Plans. This plan emphasizes the need to track performance measures that are necessary to provide information at the BiOp check-ins, and for annual implementation planning. The BiOp specified two tiers of status monitoring that have been incorporated into this framework.

(1) Ecosystem/Landscape

Ecosystem or landscape scale monitoring is intended to provide a broad overview of anadromous salmonid population distribution and habitat condition across the listed ESUs. It corresponds to Tier I level monitoring described in the BiOp. The objectives are to:

- Identify the entire geographic range used by ESA listed anadromous salmonids in the Columbia River Basin.
- Detect changes in population distribution.
- Identify key landscape scale habitat attributes.
- Identify associations between salmonid presence and habitat attributes.
- Ground-truth and update habitat databases.

Ecosystem monitoring has the following general features:

1. *Temporal scale* – Compilation of information should occur every 5 to 10 years.

2. *Spatial scale* – Coverage spans the entire portion of the Columbia Basin occupied by ESA-listed ESUs.

3. *Statistical properties* – Census approaches would be ideal, however systematic sampling will likely be more practical.

There are no specific quantitative performance standards or goals at the Ecosystem Landscape scale prescribed in the BiOp. Key indicators have been selected to reveal long-term temporal trends in land use, aquatic integrity, and the geographic expansion or contraction of ESUs. These indicators and guidelines for tracking them are detailed in the subgroup RME plan for population and environmental status monitoring (Appendix A).

(2) Geographic Zone

Monitoring within specific geographic zones should provide a more detailed and frequent (annual) view of fish and habitat status in areas of known salmon and steelhead distribution.

The objectives are to:

- Document changes in adult and juvenile population abundance of ESUs.
- Estimate key life stage survival rates.
- Track changes in key environmental/habitat indicators.

This type of status monitoring has the following features:

1. *Temporal scale* – Sampling occurs annually or more frequently, depending on the indicator.

2. *Spatial scale* – The geographic scale will be dictated primarily by the population unit(s) designated through the Technical Recovery Teams (TRTs). The AAs and NMFS expect that most efforts will generally occur at the subbasin level.

3. *Statistical properties* – Unbiased estimates are assumed, with accompanying measures of precision preferred (Precision should always be reported, even if it is not measured).

(a) Tributary Zone

Biological Performance Standards – For many ESUs, the tributaries are the locations where spawner escapement will be estimated. These estimates will then be used as the foundation for conducting population-level performance standard tests as described in the BiOp.

Environmental Performance Standards – No quantitative standards were specified in the BiOp. The AAs and NMFS will be working with USFWS, USFS, BLM, and EPA within a Federal Caucus RME workgroup in the first half of 2003 to develop these standards.

Indicators – Biological indicators for estimating spawner abundance can include, redd counts, or weir counts with appropriate expansion factors included. Some ESUs necessarily rely on dam counts to estimate spawner abundance (e.g., Snake fall Chinook). To document spawner abundance, we consider the mainstem as the destination tributary for such populations. Juvenile abundance indicators are also useful, but not critical for use in BiOp performance tests. Juvenile fish indicators can include parr density, smolt abundance estimates from trapping sites, and required expansion factors. Details regarding indicators are specified in the subgroup RME plan for population and environmental status monitoring (Appendix A). Candidate environmental indicators are listed in that same appendix.

Guidelines – Guidelines for monitoring these biological and environmental indicators have been developed and appear in Appendix A as well.

(b) Hydro-Corridor Zone

Performance Standards – The BiOp specified survival standards as biological goals for salmonids migrating through the FCRPS. Standards were established for both juvenile and adult life stages. At the out-year check-ins, more formal quantitative tests are envisioned and by 2010 the standards are to be achieved. Status monitoring in the hydro-corridor involves estimating survival of these life stages annually and compiling a historical profile where possible. The testing protocols for determining progress and ultimately compliance, as described in the BiOp, are general and required clarification by the Hydro workgroup, as described in the RME plan (Appendix C). The AAs place a high priority on conducting the monitoring required to assess compliance with the BiOp Hydro performance standards.

Indicators and Guidelines – The indicators include estimates of smolt and adult survival during migration through the FCRPS (or around it in the case of transported smolts). Baseline estimates are available for some years commencing in the 1990s. Guidelines and details regarding experimental and analytical protocols are presented in the hydro RME plan (Appendix C).

Additional indicators will include estimates of “D” that emerge out of critical uncertainty research actions, as described in a later section of this plan.

(c) Estuary/Ocean Zone

The BiOp did not establish explicit performance standards for the ocean/estuary environment. However, the Technical Recovery Team for the Willamette and Lower Columbia River is currently attempting to develop performance goals. These goals may prove be applicable with respect to status monitoring in the estuary. Note that a lack of performance standards for the estuary does not preclude development of performance measures and indicators. Essential indicators will ultimately be derived from ongoing research and planning efforts in the estuarine ecosystem. Furthermore, the estuary/ocean RME program called for in RPA Action 161 will address performance indicators and standards when the program is developed.

B. Action Effectiveness Research

Introduction

The objective of action effectiveness research is to establish the cause and effect of actions on fish survival, fish condition, and habitat condition in a quantitatively rigorous approach. This information will be critical for projecting expected benefits of hydro and offsite mitigation actions (collectively habitat, hatchery, and harvest actions) at the check-in evaluations. This research requires well-designed experiments, with treatment conditions or areas, controls, and adequate replication. Casual monitoring will not meet the objectives of this RME component.

Performance Standards – The BiOp identified a generic class of quantitative standards for the non-hydro actions associated with collective offsite mitigation projects. This includes projects initiated under the auspices of the BiOp, as well as those performed by other regional agencies under the All-H Strategy and the NWPPC Fish and Wildlife Program. The BiOp (Table 9.2-4) provides the estimated percent change in survival throughout the life cycle that is needed to achieve survival and recovery criteria. These standards represent the collective improvement in survival across all life stages apart from any hydro-related effects, but offer no guidance for selecting indicators. At this time it is not clear to the RME team how estimates of survival improvement across collective habitat, harvest, and hatchery actions will be acquired. It is likely some model will be required to account for collective gains and losses and to predict the net outcome. That model has not been selected, and may not exist. The current thinking is that the survival improvements demonstrated through well-designed AER projects will be the input for such a modeling exercise. In the absence of a suitable model, opportunities to synthesize the diverse set of inputs are not readily apparent.

(1) Habitat AER

(a) Tributary

The BiOp emphasizes the need for action effectiveness research in tributary habitat. RPA 183 specifically calls for a suite of experiments to be conducted for different types of habitat actions across a complex of ESUs.

Tributary management action categories include:

1. Irrigation diversion screening

2. Barrier removal

3. Sediment reduction

4. Water quality improvement

5. Nutrient enhancement

6. Instream flow restoration

7. Riparian function restoration

8. Stream complexity restoration

The primary purpose of action effectiveness studies is to generate information to evaluate tributary habitat actions at the 5-year and 8-year check-ins. This information will also help guide future subbasin planning efforts by quantifying the relative effectiveness of different types of actions. The BiOp specified no quantitative performance standards for such experiments. The action plan (Appendix B) calls for a two-pronged approach to the experimental design problem.

The first is a series of formal experiments to address the question of whether or not classes of actions affect environmental conditions, fish distribution, and ultimately survival. For this approach to work well, however, actions must be spatially isolated so that their effects can be studies in detail in the absence of other types of actions.

However, many subbasins will have several types of action occurring in close proximity to one another. Therefore, the second prong is to monitor the sites of all habitat actions that are intended to increase survival rates of listed stocks in three subbasins, along with control sites that are similar to action sites, but with no planned or ongoing actions. This experimental design is intended to assess the effects of many different combinations of actions on the fish and their environment.

Indicators – The most instructive response or indicator is the change in fish survival at one or more life stages that is attributable to specific management actions. However, actions first alter environmental conditions, fish distribution (for example, for barrier removal), and finally fish survival. The change in survival may not be fully manifested by the 8-year check-in, and it may be difficult to isolate the causal agents. For this reason, studies should also track the response of environmental attributes and fish distribution as early indications of success. Candidate attributes are presented in the AER-Tributary workgroup RME plan (Appendix B).

Guidelines – Since these experimental designs are formal field experiments, traditional guidelines associated with sound scientific method apply.

(b) Estuary/Ocean

The BiOp clearly underscored the need to understand the effects of FCRPS operations on the estuary ecosystem. One tool to address this charge is a physical, numeric model of water flow and circulation in the estuary. Such a water model is currently being developed. Ideally, this model will provide inputs to a model of the estuary ecosystem that links biological and physical processes. A model of the Columbia Estuary ecosystem is planned in Project 30001 (Table X+1) and when completed will satisfy this RPA action.

(2) Hydro AER

The BiOp calls for action effectiveness research at many mainstem projects to detect local effects of alterations in turbines, bypass systems, spillway operation, and adult passage systems. Hydro effectiveness research almost entirely falls under the purview of the Corps AFEP to prioritize and conduct research. No performance standards are specified.

Indicators – The responses that are tracked under this category of research include juvenile and adult survival past dams and through various passage routes, fish migration rates, route-specific fish passage efficiency, etc.

Guidelines – These studies fall under the auspices of the Corps AFEP, and are subject to research guidelines specific to that forum.

(3) Hatchery AER

Action Item 184 of the BiOp calls for action effectiveness research involving the use of artificial production (hatcheries). The required research is directed at two questions:

- Do hatchery reforms reduce the risk of extinction for Columbia River basin salmonids?
- Do conservation hatcheries (or hatchery activities) contribute to recovery?

These questions are analogous to those addressed by action effectiveness research for tributary habitat actions. In both cases, the objective is to establish the cause and effect of actions – in this case the effect of hatchery reforms or conservation hatchery activities – on fish survival using a quantitatively rigorous approach. Controlled experimentation is necessary to isolate the effect of a particular reform on the survival of the hatchery fish involved and/or effects of those hatchery fish on natural populations, the latter often brought about through a reduction in deleterious effects on the natural populations. The primary purpose of these experiments is to generate information to evaluate hatchery reforms and conservation hatchery activities at the 5-year and 8-year check-ins prescribed in the BiOp and, more generally, to better inform recovery efforts throughout the basin.

Performance standards and indicators – Hatchery reforms and conservation hatchery activities are management actions, meaning they are purposeful manipulations of specific variables that should be evaluated using controlled scientific experiments. As is the case with habitat actions, no standards specific to hatchery reforms is established in the BiOp. Rather, the BiOp specifies a standard in terms of overall (all-h) survival improvements needed for each ESU (Table 9.2-4). Although many hatchery reforms have been implemented in programs throughout the basin, few are based on rigorous experimentation. The indicators for most hatchery reforms and many conservation hatchery activity experiments would consist of incremental improvements in survival measured, as a practical matter, at a particular life stage rather than across the entire life cycle. This implies use of a model or models, developed external to the specific reform experiments, to evaluate the overall effect of the reform on survival of the population or ESU of interest, and to synthesize these effects with those resulting from habitat, harvest, and hydro actions.

Hatchery Reforms AER

RPA 184 calls for studies – experiments – directed at determining the extent to which hatchery reforms reduce extinction risk to listed populations. Some hatchery reforms seek to reduce deleterious ecological, genetic, or management effects of hatcheries on natural populations. Altering release practices, for example, may reduce ecological effects on listed fish such as predation and competition. Using local rather than nonlocal brood stocks, or controlling unwanted straying by, for example, improving homing of supplementation fish might reduce deleterious genetic effects to listed populations. Marking hatchery fish to facilitate better accounting of hatchery and natural origin fish in the escapement would facilitate improved assessments of the status of wild populations and/or enable fisheries to selectively harvest nonlisted fish while limiting impacts on non-target species.

Other reforms seek to increase the survival rates of hatchery fish, which typically are lower than naturally produced fish, or alter the spatial and temporal distribution of returning hatchery fish. The potential benefits to listed fish of such reforms may be manifest in several ways. Hatchery programs used, for example, to reintroduce fish to areas where they had been extirpated (assuming the right choice of hatchery broodstock), may provide greater net benefits to an ESU if homing could be improved, perhaps using acclimation ponds or other reforms. The benefit of a reform may be indirect; for example, if survival rates of hatchery fish produced for mitigation or fishery augmentation purposes can be increased, fewer would need to be produced, thereby reducing costs and, potentially, the extent of negative ecological interaction with juvenile listed fish.

(a) Conservation Hatcheries AER

The second category of AER called for in RPA 184 involves conservation hatchery activities. Included in these activities are captive brood and captive rearing programs, some supplementation and reintroduction programs distinguished as a group by their focus on conservation and recovery rather than fishery objectives, at least in the near term. Many hatchery programs in the basin are justified by their sponsors as conservation activities, yet their ultimate effectiveness in contributing to recovery is unproven. As is true for hatchery reforms, many conservation hatchery activities will be evaluated in terms of their effect on a particular life stage for a particular group of fish; quantifying their contribution to recovery likely will require reliance on models developed specifically for the purpose of synthesizing and analyzing the effects of many types of activities on recovery of the ESU.

(4) Harvest AER

In recent years, the region has moved toward greater selectivity in harvest to reduce impacts on depressed populations while allowing harvest of abundant runs. The general approach is to utilize gear or methods that allow the fishermen to release nontargeted fish or avoid them altogether.

There are two key questions raised by this shift in fishery management: (1) whether and to what extent fish that have been caught and released from selective fishing gear survive to successfully reproduce, and (2) whether the gear or method is effective at catching the target species. There have been relatively many tests of the latter question over the years, but too little focus has been given to the first question. Yet, the ultimate effectiveness of selective fisheries depends on the extent to which the non-targeted species, often listed fish, survive the fishery. Those studies that have focused on the survival of released fish typically have been limited to short-term survival following encounter with the gear. What is needed is evaluation of the effect of catch and release on spawning success.

C. Critical Uncertainty Research

The primary objective of critical uncertainty research is to resolve key issues that emerged in the BiOp population modeling analyses associated with risk assessment. These are critical areas of uncertainty that focus on determining survival associated with particular processes. They include: the reproductive success of hatchery fish spawning in the wild, the magnitude of delayed differential mortality associated with transporting smolts (D), and quantifying the extent of extra mortality (EM) and identifying its causes. The ability to resolve these uncertainties will be a critical element in the confidence of the check-in evaluations.

(1) Relative reproductive success of hatchery fish

One of the critical uncertainties identified in the BiOp has to do with the relative reproductive success of hatchery fish spawning in the wild. This uncertainty is the focus of RPA 182. As a result of the extensive use of artificial production, many populations in the Basin are now comprised of a mix of natural-origin and hatchery-origin spawners. This circumstance presents two kinds of problems, one biological and one data-related, which combine to mask the true status of natural populations in the Basin, and is referred to here as the "masking problem."

The biological aspect of the masking problem stems from peer-reviewed studies indicating that hatchery-origin spawners have lower reproductive success when they spawn in the wild than natural-origin spawners. Uncertainty about relative reproductive success of hatchery fish required the status assessments contained in the BiOp to rely on a large range (e.g., 20 percent to 80 percent) for the relative reproductive success of wild spawning hatchery fish compared to natural origin fish. This parameter greatly affects conclusions regarding the status of the wild population and the improvement needed to meet ESA survival and recovery objectives. The BiOp RPA 182 calls for research to address the critical uncertainty regarding the relative reproductive success of hatchery fish spawning in the wild.

(2) Differential Mortality of Transported Fish (D) (to be added)

(3) Extra Mortality (EM) (to be added)

D. Project Implementation and Compliance

The objective of this category is to document that management actions have been executed as prescribed in the BiOp. It involves having Contract Officers Technical Representatives (COTRs) track the execution and location of the management projects and determining if they are in compliance with the specifications in the directive or work statement. In some cases such compliance monitoring may extend beyond the implementation phase. For example, it will be necessary to ensure that riparian fencing remains in place for some extended period beyond the construction phase. A project tracking system needs to be developed to manage this information.

E. Data Management

Data management is a principle component within the BiOp RME Plan. In addition to supporting the assessment objectives and RME RPA actions within the Plan, the NMFS BiOp RPA action 194 specifically calls for the Action Agencies to develop a common data management system for fish populations, water quality, and habitat data in coordination with NMFS, USFWS and other Federal agencies, NWPPC, states, and Tribes.

The Action Agency data management work plan identified four areas of need for meeting the requirements of the BiOp:

- A more comprehensive scoping of existing regional data management projects/goals/needs
- A formal comparison of regional data management goals/needs compared to the FCRPS BiOp goals/needs
- The development of a FCRPS RME information system architecture or blueprint that is consistent with regional needs
- The development of an information system(s) from the ground up in a modular fashion so that the system(s) meets the practical needs of the local users while meeting the legal and administrative requirements of the region

These needs will be filled by: (1) participation in the development of a regional (common) data management system while providing real-time data management support for the research, monitoring and evaluation needs of the BiOp; and (2) implementation of a data management prototype for tributary habitat in the three subbasins that are proposed for status and effectiveness research monitoring. The work plan lays out a series of work tasks and associated schedules and costs.

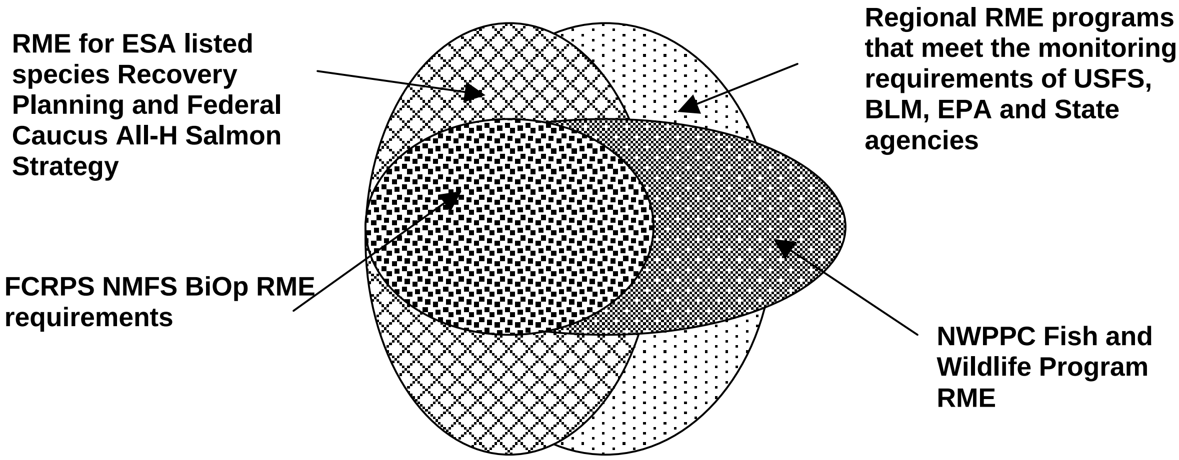
Decisions to move forward on RME data management are urgently required. A high level of interagency coordination and cooperation will be necessary to develop successful prototypes and systemwide data management programs. Formal agreements may be required for cost sharing, data standards and data sharing protocols.

F. Regional Coordination

Currently there is a broad patchwork of regional RME efforts in different phases of planning, development, and implementation that could benefit from increased coordination. The NMFS FCRPS BIOP, the Federal All-H Strategy, and the NWPPC Fish and Wildlife Program all call for RME programs. In addition, there are existing Federal programs that focus on monitoring freshwater habitat and environmental conditions, such as the Forest Service and Bureau of Land Mangement’s Northwest Forest Plan and Pacfish/Infish Biological Opinions and EPA’s EMAP program. At the state level, both Washington and Oregon have formulated their own plans for monitoring freshwater habitat conditions. There also are collective efforts such as the Lower Columbia River Estuary Program (LCREP), a joint program involving agencies from

Washington and Oregon, federal agencies, and local jurisdictions. These monitoring programs overlap one another at various spatial and temporal scales (see Figure 1).

Figure 1. Regional RME needs - cross coverage:



The FCRPS RME Program overlaps with other regional programs having their own needs and geographic coverage. The NMFS and the AA intend to implement a RME program, for which major components must be in place by 2003, that addresses the NMFS BiOp requirements for ESA-listed salmon and steelhead stocks. This RME program will be coordinated with other Federal, state, and tribal programs and take advantage of the current monitoring data and overlapping monitoring programs. NMFS and the Action Agencies are attempting to cooperatively develop the FCRPS RME Plan with the intent that it will also complement and be integrated within the other regional monitoring activities to the greatest extent practicable. This coordination will be essential to maximize the amount and quality of RME across the region within limited budgets. Both the Action Agencies and NMFS recognize that the various programs have different goals and objectives, and that this will preclude regionwide reliance on any single monitoring program until much broader and comprehensive multi-agency agreements on RME have been developed.

A Federal Caucus RME workgroup has recently been formed through the Federal Caucus to provide regional coordination and points of interface between the NMFS BiOp required RME program and other Federal RME programs, and ensure that the Federal Caucus meets the RME requirements identified under the All-H Salmon Strategy. The USFS and BLM have been coordinating their AREMP and PIBO monitoring programs with EPA and the states over the past several months, and the Federal Caucus RME group is now pursuing the expansion of this ongoing partnership forum to include the NFMS and AA BiOp RME Program. As this effort expands, there will be additional efforts to include RME efforts associated with the USFWS bull trout recovery planning, NWPPC Program, and tribal RME programs in this coordination. In addition, there is a project proposal from CBFWA through the Mainstem/Systemwide Provincial Review for RME coordination with state and tribal fish agencies that may include deliverables that would advance coordination with the NMFS BiOp RME Program. Currently the Federal Caucus RME workgroup has proposed the following coordination meetings on a regular basis to advance coordination.

1. Federal, State, and Tribal Monitoring Partnership Meeting (meeting once a month)
   Addresses big picture issues for coordination across regional RME programs and needs.

2. Federal Caucus RME Meeting (meeting once a month)
   This is the current Federal Caucus RME workgroup that will continue to meet on Federal All H policy and big picture issues for meeting Federal Caucus RME goals.

3. Technical Group Oversight Meetings (meeting 3 times a month)
   This is the current NMFS/AA RME Planning Group expanded to the Federal Caucus Level to provide oversight and direction to expanded RME Technical Workgroups.

4. RME Technical Subgroup Meetings (meetings scheduled as appropriate by workgroup leads)
   These are meetings of the existing NMFS/AA RME Workgroups (Status Monitoring, Tributary Action Effectiveness Research, Hydro, Hatchery/Harvest, Ocean/Estuary, Data Management) that will be expanded to include broader Federal (and possibly state and tribal) participation.

The primary coordination objectives of these groups will include:

- Coordinate federal, state, and tribal RME requirements and associated programs.
- Identify cost sharing opportunities and agreements.
- Coordinate research methods, data collection, and reporting protocols. Recommend ways to standardize these elements.
- Identify opportunities and recommend collaboration or combination of studies to increase learning and statistical power of studies.
- Provide a point of contact for integrating TRT monitoring requirements with regional monitoring programs.
- Assist with integrating F&W Program objectives, funding prioritization, and Subbasin Planning efforts with other regional RME efforts.

Additional direct coordination is envisioned to occur over the next year through the implementation of status monitoring and action effectiveness research pilot studies in the John Day, Wenatchee, and Upper Salmon. Key objectives of these pilot projects include working with regional entities at the implementation level to identify how best to integrate and coordinate with other RME programs and objectives.

III. Executive Summaries of Workgroup RME Plans

A. Population and Environmental Status Monitoring Workgroup Plan

(1) Executive Summary

The goal of population and environmental status monitoring as proposed under the NMFS 2000 Federal Columbia River Power System Biological Opinion is to provide the necessary data for resolving a wide range of uncertainties, determining population status, establishing the baseline for the causal relationships between habitat attributes and population response, and facilitating the assessment of the overall impact of management actions.

Action Items 180 and 181 outline the scope and scale of a hierarchical monitoring program with two levels of status monitoring (Tier1 and Tier2). In addition, the status monitoring program is further developed in Appendix G. However, the RPAs 180 and 181, Appendix G, and the body of the FCRPS BiOp do not fully specify the details of a comprehensive status monitoring program such that an implementation plan can be readily developed. The purpose of this document is to specify many of the undefined aspects of the status monitoring program and outline an action plan for its further development.

Questions to be answered by the Status Monitoring program include the following:

Ecosystem status questions

What is the distribution of adult salmonids?
What is the ecosystem status for Columbia River Basin (CRB) fish populations?

Population and habitat status monitoring questions

What is the size of CRB fish populations?
What is the annualized growth rate of CRB fish populations?
What is the freshwater productivity (e.g., smolt/female) of CRB fish populations?
What is the age-structure of CRB fish populations?
What is the fraction of potential natural spawners that are of hatchery origin?
What is the biological condition of CRB fish spawning and rearing habitat?
What is the chemical water quality in CRB fish spawning and rearing habitat?
What is the physical habitat condition of CRB fish spawning and rearing habitat?

(a) Status Monitoring Performance Standards

The FCRPS BiOp uses Performance Standards as the metric by which implementation of the RPAs will be assessed. Performance standards for the RPAs derive from the biological requirements of the listed populations at the life-cycle and at each life stage. FCRPS BiOp performance standards are defined in three tiers. The most general tier is the population level performance standards. These standards define the performance needed for the listed population to achieve adequate likelihoods of survival and recovery. Life stage-specific performance standards at the intermediate tier allocate across the life cycle the performance expectations necessary to achieve the population-level standards. This tier guides the development of performance standards for categories of actions in habitat, harvest hatcheries, and hydropower. The third-tier standards are intended to achieve the life-stage standards.

The FCRPS BiOp explicitly calls for particular biological indicators to be monitored in specifying tests that will be applied at the check-ins. At this level there are four specific population level check-ins requiring population numbers and productivity assessments (FCRPS BiOp, 9.2.2.1). Satisfying these check-in assessments arises directly from the status monitoring program.

The Action Plan for the population and environmental status monitoring program of the FCRPS BiOp addresses the following items:

- Define the Status Monitoring component of the FCRPS RME program.
- Define the relationship of the Status Monitoring program to the other FCRPS RME components.
- Generate detailed guidance for a Status Monitoring program.
- Identify performance standards for the Status Monitoring program.
- Identify the degree to which status monitoring is currently being successfully implemented, including the gaps in current work in terms of occurance/non-occurance as well as quality of the information generated. Incomplete or inadequate monitoring programs need to be identified so they may be improved or replaced to achieve a consistently adequate monitoring program.
- Identify the structure of handling, storing, and disseminating data generated by the monitoring program to enable appropriate status evaluation.
- Identify strategies for design of evaluation or decision making and planning tools.

(b) Statistically based sampling design for status monitoring

It is obviously impossible to monitor everything, everywhere. Therefore, for the systemwide status monitoring program to be both accurate and cost-effective, data must be gathered using a rigorous, unbiased sampling design. Sampling designs for spatially explicit data such as habitat surveys are quite complex. The design must provide information on status and trends in abundance, geographic distribution, and productivity of listed anadromous populations and their habitat at the population-to-subbasin scale. It must estimate these quantities with no bias and known precision. The primary concern is selecting sites across a large spatial area without inflating the variance or biasing the estimate. Use of the traditional approach, simple random samples, has the potential to inflate variance and bias the estimators because the samples can end up clumped in space. The next generation of sampling schemes, stratified random sampling, addresses the spatial distribution of sites if the strata are themselves evenly distributed, but has the potential to introduce hidden biases if the strata are not correctly chosen. In addition, stratification always requires more samples to maintain power across strata. For landscape-scale sampling the ideal system has built-in spatial distribution—sampling on a grid rather than randomly across space.

(c) General description of current projects and programs

At the ecosystem scale, there have been several comprehensive one-time data collection efforts. For example, NWPPC Subbasin Assessments require the compilation of some, but not all, data layers recommended by the FCRPS BiOp status monitoring program. In addition, the Interior Columbia Ecosystem Management Project (USFS/BLM) has assembled a large collection of spatial data layers that are relevant to ecosystem scale status monitoring. However, both of these assessments are one-time data gathering efforts to support long-term land use and management planning. As such, they may form the first round of ecosystem scale status monitoring data collection, but an ongoing periodic program will need to be established. This is one major gap we have identified to date.

At the subbasin scale, there are numerous state and tribal annual sampling programs targeting salmonid fishes, and to some extent their habitat, distributed across the Columbia River basin. For a summary of these programs, see the attached spreadsheet (SM_Action_Plan_Table.xls – 1. – 6.) of the status of status monitoring programs. While there are a large number of status monitoring programs currently underway in the Columbia River basin, there is little coordination of these programs across administrative boundaries, and as such, the resulting status monitoring data may not be adequate to address regional or basinwide management needs. The subbasin scale status monitoring program outlined in this document was generated to meet the basinwide management needs in that it attempts to unify the approaches to the monitoring of status and trends of salmonid populations and their tributary habitat environment. The plan to implement such a status monitoring program is presented in the following section; in particular, the staged implementation of pilot projects, and the mechanisms by which a large-scale cooperative program could be developed by building on existing status monitoring programs.

A gap assessment is ongoing (see **Appendix X**). We propose to begin a number of pilot projects to address the gaps identified to date.

(d) Pilot Projects

The initial phase of basinwide implementation of a FCRPS BiOp motivated status monitoring program will be subbasin scale pilot programs: an assessment of ecosystem scale status monitoring approaches based on remote sensing data in the John Day and upper Salmon River basins; and status and trend monitoring efforts for anadromous salmonids and their habitat in the Wenatchee, John Day, and upper Salmon River basins.

Pilot projects will be supported by previously acquired satellite imagery, and will be most useful if coordinated with subbasin scale habitat and population monitoring pilots for data sharing and ground truthing. Specifically, the pilot projects must each address the following list of issues.

Change detection
Practicality of ecosystem monitoring via remote sense data

The status and trend monitoring program for anadromous salmonids and habitat in the Wenatchee, John Day, and upper Salmon River basins will serve three major data collection efforts:

- At the scale of a subbasin, assess on an annual basis the status of adult populations of anadromous salmonids.

- At the scale of a subbasin, assess on an annual basis the population status or productivity of juvenile anadromous salmonids.

- At the scale of a subbasin, assess on an annual basis the status of salmonid habitat.

The status monitoring program development as proposed herein will require extensive collaborative work with ongoing research and monitoring programs. The ecosystem scale pilot projects will require extensive collaboration with regional data management entities, as well as a wide range of resource management agencies currently doing landscape assessments (e.g., States, USGS, USFS/BLM) and research units developing novel approaches and techniques (e.g., OSU, PNWERC). For the subbasin scale status and trend monitoring pilot projects, the design and testing phase for this project will require collaboration with U.S. Environmental Protection Agency research staff for statistical components of the design, and subbasin planning entities for programmatic components of the design. Implementation of the status and trend monitoring program will require extensive coordination with local co-manager groups in each subbasin.

B. Action Effectiveness Research (Tributary Habitat) Workgroup Plan

(1) Executive Summary

The BiOp calls for assessing the effectiveness of tributary habitat actions in RPA 183 and elsewhere. Effectiveness, in this context, may be defined as increasing life-stage survival rates or condition of listed anadromous species, increasing local abundance by attracting fish to improved habitat, or improving environmental conditions. Because any or all of these indicators of effectiveness could change by chance or due to causes unrelated to habitat actions, the BiOp also requires that effectiveness be demonstrated via well-designed experiments – with treatment and control sites – using a statistically rigorous framework.

Because research of this type has rarely been undertaken in the past, the Action Agencies and NMFS have decided to take a two-pronged approach to the problem. The first is a traditional experimental design, designated here as a project-based approach. This will be implemented by investigating the effectiveness of up to eight categories of actions (defined in RPA 183) across one or more ESUs. Details for this approach may be found in the RFQs to be issued in December 2002. Field work will begin in the spring of 2003.

These project-based research projects are intended to provide estimates of the effectiveness of classes of habitat improvement actions on listed fish populations. We anticipate that they will be tightly focused on specific action categories and will examine project effectiveness within a rigorous, scientific, inference-testing research framework not provided by the broad-scale monitoring and evaluation in the top-down approach. We expect that data collected will be compatible with the top-down approach outlined below. A rough cost estimate for these studies (up to 16 research projects) is $8M per year if all 16 are pursued by investigators and funded by the Action Agencies.

Under the second strategy, the Action Agencies and NMFS have developed a top-down research plan whose 2003 target is listed spring/summer chinook and steelhead in the John Day, Wenatchee, and Upper Salmon subbasins. We have confined the geographic scope because we are uncertain at present how costly and extensive the monitoring will be. Because this type of monitoring has never been carried out on this scale, many logistical and project management problems will need to be solved using the three pilot subbasins. We anticipate expanding the scope substantially in 2004, to six subbasins, with more subbasins being added in 2005 to 2008. This summary presents the broad outlines of the program. Details can be found in **Appendix X**.

Each reach will be classified by ecoregion, geomorphic features, valley characteristics, etc. Early in 2003 (before the start of the field season in June) co-managers for the three pilot subbasins will be surveyed to compile a census of past, ongoing, and planned habitat actions – both those funded via the NPPC and other agencies. This survey will also gather information on the results of current biological and habitat monitoring programs. In each year from 2003 to 2008, all ongoing or proposed tributary habitat action sites will be monitored to track changes in local juvenile abundance and environmental conditions. Similar monitoring will occur at paired control sites. Using the results of ongoing efforts to enumerate redds, tag and enumerate parr and smolts, with expansion and standardization of these efforts as needed, we will compile an extensive database of life-stage survival, juvenile and adult abundance, juvenile fish distribution, and environmental conditions for the 25 to 30 sub-populations of spring/summer chinook and steelhead in the three subbasins. Data will be collected using standardized protocols, with extensive QA/QC, and be made available to interested parties within 6 months of collection (e.g., data collected in 2003 will be available by spring of 2004).

Data will be collected using the same protocols in all locations, and similar data will be available for both treatment and control sites. A very rough estimate is that perhaps several hundred treatment (habitat action) sites will be monitored, with a similar number of control sites. This can therefore be viewed as a very large-scale experiment, with several hundred treatment and control sites, and roughly 3 to 4 action sites per sub-population. The data will be analyzed using standard statistical techniques to help answer a variety of questions at different spatial scales. Examples include:

1. Did a given single habitat action work in the sense of increasing local fish abundance or improving local environmental conditions, compared to a similar, nearby control site?

2. Did all actions in aggregate for a given sub-population increase juvenile survival or adult abundance, compared to a similar sub-population with few or no actions?

3. Did some types of actions (e.g., riparian planting) perform better than other action types (e.g., irrigation screening) in improving localized conditions or sub-population juvenile survival rates?

4. What contribution did all habitat actions for an entire ESU make toward increasing the ESU-level population growth rate?

Much of the data will also be useful for status and trend monitoring. Use of the data in that context is covered elsewhere in this document.

While the RM&E group believes that the proposed research plan is feasible, many institutional, logistical, and practical problems need to be solved to make the plan work. No existing data base contains a complete census of ongoing habitat work. To monitor these sites, we must know precise locations, when work began, what is being done, and who is responsible for the projects. No existing tributary monitoring program approaches the geographic scale and level of detail that is proposed here, nor are any directed at the effectiveness of habitat actions.

Data reporting may also be problematic. Few if any projects presently report the environmental and survival effects of habitat actions. Monitoring data are often shared reluctantly, or in highly aggregated form, years after they are collected in the field. In marked contrast, under this plan data must be made available to all interested parties soon after it is collected in the field. For analysts to be able to make useful comparisons across the study area, data collection protocols must be standardized. QA/QC, including resampling by field workers not part of the original collection effort, will be essential to assure the accuracy of the data used in the effectiveness analysis.

The schedule is demanding as well. The habitat action and monitoring data surveys must be completed by March or April 2003; contracts for field surveys must be finalized about the same time so that training can commence in April-May and field work start in June. Equipment for field workers, permits, etc. will obviously be needed as well. A very rough estimate for budget is perhaps $100K one-time cost for the habitat action/biological monitoring surveys of co-managers, and $1.5M to $3M annually for detailed habitat and juvenile fish surveys at treatment (habitat project) and control sites, additional monitoring of adult and juvenile abundance and survival rates, data management, and analysis. The monitoring of abundance and survival rates overlaps with status monitoring. Costs will obviously increase as subbasins are added in 2004-2008. By way of comparison, the COE mainstem research program costs about $30M per year.

C. Hydro-system Workgroup Plan

(1) Executive Summary

This plan addresses RME issues that are directly associated with the FCRPS hydrosystem, particularly with respect to effects on life stages directly impacted by the dams and their operation. The objectives of the activities specified in this plan are to:

- Satisfy hydro-related RME RPAs presented in the FCRPS BO, and
- Develop an approach for evaluating progress toward and compliance with survival performance standards specified in the BO.

In this plan the Hydro Workgroup will:

- Identify key performance indicators and standards. Performance indicators are responses or conditions that are monitored. They are either biological or environmental.
- Assess research and monitoring needs – gap analysis. This involves a description of RPA requirements, RME projects satisfying each RPA, the identification of deficiencies and recommended remedies.
- Present guidelines for conducting RME, if applicable.
- Perform Status Monitoring
  - Recommend approaches for conducting the required RME

  - Identify options for testing progress towards and compliance with numerical standards presented in the BO.
- Perform Critical Uncertainty Research
  - Describe project coverage of CU RPAs,
  - Assess the connection between RPA expectations and true research capabilities, and
  - Offer recommendations if disconnects are apparent.
- Action Effectiveness Research – is briefly treated. Defer to the AFEP planning process.

Performance Standards and Indicators – The 2000 FCRPS Biological Opinion identifies two general categories of PS: life stage survival rates and physical/environmental conditions. The monitoring these constitute status monitoring as prescribed in the BO. Physical performance standards (BO Section 9.2.3) take the form of guidelines for operating the system. They include flow targets and spill schedules. Life stage survival standards are prescribed for juvenile and adult life stages.

RME Needs – The HWG reviewed ongoing, planned, and proposed research to determine if RME RPAs were being adequately addressed. Their survey indicates that all hydro RME-RPAs are being actively pursued at some level. A detailed gap analysis found the following deficiencies.

With respect to survival monitoring, there are a variety of projects that are producing survival estimates in the mainstem. All of these studies employ state-of-the-art technologies and survival estimation protocols. However, it is not possible to determine whether these projects will generate a suite of survival estimates that will be entirely adequate to satisfy BO requirements. The difficulty lies in the generality of the BO with respect to specifying quantitative tests envisioned at the check-ins.

If a gap exists, it is the absence of clear direction describing how progress and compliance with PS will be assessed. The solution will involve an analytical exercise to be conducted by the Hydro Work Group and ultimately included in later versions of this plan.

Critical Uncertainty Research – There were two critical uncertainties that emerged in the CRI BIOP analysis that are linked to FCRPS effects on listed stocks: (1) the extent of delayed effects associated with transporting smolts (D), and (2) the existence and extent of extra mortality (EM) associated with smolt passage in-river.

Although several studies will produce estimates of D, the Hydro Work Group needs to provide the community with an assessment regarding the adequacy of these estimates in satisfying BO assessments. This assessment will continue as new estimates are generated.

Although three project/proposals address important issues associated with EM as related to hydro-system experience, it is not clear that they individually or collectively satisfy the primary intent of RPAs 188, 189 and 195. Overall, the collective EM-targeted research projects will likely fall short of the expectations and needs expressed in the BO.

However, any shortcoming appears not to be associated with the capability of the research community, but rather the unreasonable nature of the requests and expectations posed in the BO under this RPA. Even so, the collective research will expand our understanding of delayed effects associated with dam passage, but not necessarily resolve all outstanding EM issues identified in the BO. To fill the gap between expectations and feasibility, the managers who drafted the RPA and researchers who are attempting to satisfy it need to discuss and resolve the apparent disconnect.

Hydrosystem - Action Effectiveness Research – RPA 199 directs the AA to fund a variety of research actions (RAs) that are largely action effectiveness research projects. The gap analysis conducted by Fisher (2002) lists these RAs in his appendix Table A8. Each of these RAs has at least one research or evaluation project associated with it. Coverage is complete. Since the COE funds these projects, the adequacy of the research is assessed through the AFEP forum. The work group relies on that technical forum to establish focused research projects.

(2) Action Plan

Monitoring Survival (Status Monitoring) – The objective of monitoring activities in the hydro corridor is to assess progress toward, and ultimately achieving, the life stage-specific survival performance standards prescribed in the BO.

ESU-specific monitoring – To accomplish this, for each ESU the work plan identifies:

- Appropriate performance standards,
- Appropriate experimental protocols (including tools) and analytical models, and
- Appropriate populations to be used as experimental or index groups.

Survival Standards – The BO identified three classes of smolt survival as candidate performance standards:

- Project (dam and pool),
- System (in-river through the FCRPS), and
- Combined, which includes survival of smolts migrating in-river, as well as those transported, and includes an estimate of any delayed transport effects (D).

For each ESU, the plan identifies a primary survival performance standard that would be the most useful in gauging the status of that population unit. When the primary standard proves to be too limiting or impractical to obtain, then alternative standards and associated performance measures are proposed. To arrive at that point requires several steps. For each ESU the HWG will:

1. Review any proposed quantitative tests as described in the BO, and identify alternative tests that could be conducted at the check-ins where necessary. Consider the statistical nature of key candidate response variables (e.g., in-river survival, D, etc.).
2. Identify demographic units for which survival estimates can be practically obtained and effectively tested (e.g., a specific ESU or an index group comprised of wild or hatchery populations, or a composite index for each species). Often wild fish comprising the ESU cannot be tagged in sufficient numbers to provide useful estimates, in which case surrogate populations must be selected.
3. Determine what data or estimates are needed for each demographic unit in order to conduct the tests (reach survival, project survival, etc.).

4. Assess the feasibility of acquiring that data with sufficient accuracy and precision to ensure meaningful tests at the check-ins.

5. Reassess steps 1 and 2 based on findings at step 4.

6. Identify the following for each ESU:

    a. Preferred survival estimate to use as an indicator (combined, system, etc.),
    b. Experimental stock,
    c. Tool (PIT, radio tag, other),
    d. Performance tests (statistical), including pass/fail criteria, and
    e. Historical baseline dataset, if applicable.

As of December 2002 the work group has focused on the juvenile life stage for Snake River spring/summer chinook and steelhead. This effort has proved more demanding than expected, and several important issues are still unresolved. Those include settling on reliable and useful D-estimates and crafting performance tests for the check-ins that are definitive. Here we report progress to date on those Snake River stocks.

Snake River – Spring/summer chinook and steelhead
Since these two ESUs are subjected to transport at Snake River dams, the primary PS is the combined survival for in-river and transported fish. To calculate this value on an annual basis requires that a suite of performance measures be acquired each year. These include estimates of:

- In-river survival from the head of LGR pool (ideally) to the tailrace of Bonneville Dam
- Direct transport survival from collection through liberation
- D-delayed effects associated with the transportation process

Experimental protocols and models – *In-river survival* estimates should remain consistent with those calculated and reported by NMFS since 1994 for LGRpool-BONtailrace (See Attachment 1). *Direct survival during transportation* is presumed to be a constant 98 percent, but this value is based on anecdotal observations only. The HWG recommends that some effort should be expended to empirically establish the actual value.

D-estimates (representative, accurate, and precise) are the most problematic estimates to empirically obtain on annual basis. There are several complicating factors. The HWG currently has no final recommendation as to how representative annual estimates of D can be calculated and applied in a timely manner. However we do recommend the following actions:

1. Acquire more reliable D-estimates for wild Snake stream-type populations by increasing the transported percent of PIT-tagged wild fish arriving at LGR and LGO dams.

2. By the 2003 check-in, devise a strategy which clearly describes analytical procedures regarding the application of D at the 2005 and 2008 check-ins.

Because it is not clear what values for D will be deemed to be representative and can be confidently applied at the check-ins, the hydro work group supports continuing key planned research regarding this critical uncertainty.

Populations Monitored – Existing system survival estimates are based on a composite population of hatchery and wild fish, the proportions of which can vary annually. To maintain consistency with baseline estimates, the same composite index group will be used in future assessments.

Monitoring and Generating Necessary Estimates – All monitoring should continue through at least the decade following the publication of the BO. NMFS investigators will continue to conduct research activities necessary to produce the annual estimates identified in this plan. These include annual estimates of in-river survival and appropriate estimates of D.

Snake River Fall chinook

Performance Standard (unresolved) – Since this ESU is subject to transport at Snake River dams, the most informative PS would be the combined survival for in-river and transported fish. Calculating this value on an annual basis requires that the same suite of performance measures cited previously for spring migrants be used. Unfortunately, no estimates of combined survival have ever been calculated or reported for Snake River fall chinook. Thus, no baseline estimates exist. Furthermore, there are no obvious opportunities to empirically generate such estimates. To date, it has not been possible to estimate in-river survival through the entire FCRPS. This is not expected to change in the foreseeable future. Lacking adequate monitoring capability, alternative Performance Standards may need to be considered. The HWG is exploring options with managers. As a consequence, this plan does not yet identify the preferred PS, and explores this matter in a more detailed explanation in Appendix C.

Experimental protocols and models (pending) – *In-river survival* – A major constraint to generating representative estimates of system survival through long expanses of the FCRPS lies with the inability to empirically estimate survival past Lower Monumental Dam. This reach is considerably shorter than the target reach (LGR pool to BON tailrace) specified for in-river system survival in the BO. To characterize survival through that entire expanse will require either extrapolating or modeling survival through the lower section. It is going to be difficult to accurately represent passage mortality incurred by the wild Snake River ESU, through the entire FCRPS. However, the work group recommends that two different procedures be considered as candidates for monitoring passage survival. Rely on survival estimates that:

1. Span the FCRPS, but are comprised of both empirical and model-based estimates (Attachment 2 of Appendix C).

2. Span a short segment of the FCRPS, but are comprised only of empirical estimates.

Any final decisions are deferred at this time, but the plan is to select the preferred approach following discussions with managers at NMFS and the AA.

Direct survival during transport **–** We recommend the presumed 98 percent survival estimate be verified experimentally.

D estimates – Reliable and representative estimates of D do not exist for this ESU. This is yet another constraint that negates the utility of using combined survival as a performance standard for fall chinook. NMFS investigators have initiated studies to acquire D estimates for this ESU. And the HWG recommends they continue through 2008.

Populations Monitored – Lyons Ferry Hatchery subyearling fall chinook fish will be used to generate in-river survival and D estimates. However, there is the need to continue wild fish PIT-tagging for use as a comparison. Tracking the performance of each group through common reaches will enable us to determine if the hatchery stock is consistently acceptable as a surrogate for the wild component of the ESU.

Monitoring and Generating Necessary Estimates – The HWG recommends the Snake River fall chinook transportation studies continue from 2003 to 2008. This effort could also supply the in-river migrants for use in monitoring in-river survival.

Upper Columbia (Spring Chinook, Steelhead)
Performance Standard – The primary performance standard for Upper Columbia spring chinook and steelhead is in-river system survival from McNary Dam to Bonneville Dam tailrace. Since these stocks are rarely transported from McNary Dam, in-river survival estimates through the FCRPS (system survival at BO) are the most instructive performance measures. If these stocks are transported from MCN in some years, then combined survival would be the preferred PS.

Experimental protocols and models (pending) – *In-river survival* – The Hydro Work Group has not yet decided how ***s***ystem survival will be estimated for the upper Columbia steelhead and spring chinook. Similarly, populations to be used as index groups have not been selected yet.

Continuing efforts - this version of the RME Hydro Plan is still incomplete. Important topics, including monitoring adult passage survival, progress and compliance tests, and adequacy of critical uncertainty research remain to be treated.

D. Estuary /Ocean Monitoring and Research Workgroup Plan

(Executive Summary to be added – see detailed workgroup plan in Appendix D.)

E. Hatchery / Harvest Workgroup Plan

(1) Executive Summary
The Hatchery/Harvest RME Plan addresses Reasonable and Prudent Alternative (RPA) items 182 and 184, which focus on questions involving hatchery fish and hatcheries, and item 167, which involves questions relating to harvest. The Hatchery/Harvest RME Workgroup's plans for these RPAs are summarized below.

(a) RPA 182: Relative Reproductive Success of Hatchery Spawners
As a result of years of artificial production in the Columbia Basin, many salmonid spawning populations in the Basin are comprised of an unknown proportion of natural-origin and hatchery-origin fish. Additionally, the relative reproductive success of the wild-spawning hatchery fish is uncertain, a problem identified in Section 9.6.5.3.2. of the BiOp as a *critical* uncertainty. This biological question and the counting question regarding numbers of hatchery fish spawning in the wild combine to compromise estimates of recruits per spawner, a key measure of the viability of the natural population. Widespread quantitative estimates of hatchery fish spawning in the wild, and selective estimates of relative reproductive fitness of hatchery fish are needed to increase the certainty of quantitative analyses of salmonid populations (McClure *et al.* 2000).

The immediate objective of RPA 182 is to ensure that an adequate number of studies are in place in 2003 that will begin to address the issues described above to improve status assessments called for in the BiOp at the 2005 and 2008 check-ins.

A number of studies already underway in the Basin and elsewhere will provide information relevant in some way to questions about reproductive success of hatchery fish. While useful, many of the current studies do not provide the kind of specific and quantitative results required to fulfill the purpose of this RPA item. There are, however, a few new studies (or pre-existing studies expanded to include new elements) using state-of-the-art methodologies (i.e., pedigree-based research) proposed as part of the Mainstem/Systemwide Provincial Solicitation; for the purposes of evaluating sufficiency relative to the BiOp, the Workgroup has assumed that these projects will be funded. Nevertheless, not all ESUs are addressed by the current and proposed studies, and some are directed at populations not immediately pertinent to the RPA. The Workgroup therefore believes additional studies designed to produce quantitative results on the relative reproductive success of hatchery fish spawning in the wild are needed for the following ESUs or populations: Upper Columbia steelhead ESU; Mid-Columbia steelhead ESU; and an ocean-type chinook population (either directly involving the Snake River fall chinook ESU or, if such is logistically infeasible (perhaps due to the impracticality of conducting pedigree-based research on this single-population ESU), a study focused on a suitable representative population of ocean-type fall chinook. A study focused on the Columbia River chum ESU, though of lesser importance for addressing the masking problem due to the relatively minor production of hatchery fish in this ESU in the past, could be critical to recovery planning. To obtain these studies, the Workgroup has prepared a Request for Proposals describing the needed studies. The FCRPS Action Agencies have committed to issuing a targeted solicitation in early 2003, with the objective that suitable projects can be identified and initiated in 2003.

(b) RPA 184: Effectiveness of Hatchery Reforms and Conservation Hatcheries

Action Item 184 of the BiOp calls for action effectiveness research aimed at determining whether hatchery reforms reduce the risk of extinction for Columbia River basin salmonids and whether conservation hatcheries (or hatchery activities) contribute to recovery. A specific number of studies is not prescribed, nor a specific schedule, but it is clear that priority studies designed to determine the efficacy of hatchery reforms in reducing extinction risk and whether conservation hatchery activities contribute to recovery are to be undertaken by the 2003 check-in.

The focus of RPA 184 studies should be on the effect of reforms and programs as they are currently conducted in the Basin. The study design should outline the method employed to isolate and quantitatively estimate the effect of a particular hatchery reform or conservation hatchery activity. Because most listed salmonid ESUs are comprised of multiple populations, direct measures of effect on extinction risk or recovery of an ESU will be difficult. Therefore it likely will be necessary to utilize certain indicators (e.g., fitness parameters, reproductive effectiveness, or survival rates for particular life stages) coupled with life-cycle models to estimate the effect on population growth rates (*lambda* or other appropriate population parameter), to thereby evaluate effects of reforms or conservation activities on extinction risk and recovery.

As a first step in evaluating the sufficiency of current activities applicable to RPA 184 and to facilitate the identification of gaps in existing research relative to BiOp needs, the Workgroup compiled a list of potentially relevant projects currently underway or proposed in the Mainstem/ Systemwide Provincial Review. For research directed at reforms intended to reduce extinction risk, the nature of the effects being evaluated was identified, e.g., genetic, ecological interaction, or management effects. For conservation activities, the type of activity and life stage involved was identified (e.g., supplementation). It was found that many projects exist (or are proposed) that might provide results pertinent to RPA 184, but some would require modification and/or additional analysis to address the specific needs of the BiOp. The Workgroup compared this list to a research priority scheme based on the likely effects of actions on the status of natural populations, and from this comparison a preliminary list of priority research needs was identified (see the Workgroup's Plan in the Appendix). This list is **highly preliminary** and requires further refinement.

As a preliminary result of the incomplete gap analysis described above, the potential need has been identified for additional studies, or revisions to current studies, directed at producing the specific results envisioned by RPA 184. To obtain these, the Workgroup has prepared a draft Request for Proposals describing the needed studies. Due to the very preliminary nature of the Workgroup's gap analysis, this RFP will require substantial refinement before it is released.

(c) RPA 167: Improving Estimates of Incidental Mortality in Fisheries

Accurate and precise estimates of incidental mortalities are essential to determine the extent to which fisheries impact listed fish, and are particularly critical to determining whether selective fisheries involving catch and release can accomplish their intended purposes. This is especially true in the Columbia Basin, where nearly all fisheries encounter some listed fish. Good estimates of incidental mortality are needed both in existing fisheries and any new selective fisheries such as in the lower Columbia River Tooth-Tangle fishery.

RPA 167 directs the Action Agencies to fund studies to develop improved methods for estimating incidental mortalities in current fisheries as well as those under development per RPA 164 (Development of Selective Fishing Methods and Gear). It is not specific as to number of studies or schedule (other than to require studies to be underway by the 3-year check-in), though it is clear that incidental mortality studies should accompany any study of the effectiveness of new selective fishing gears or methods. Because incidental mortality assessment is a component of current projects to test selective fisheries, no specific gap is identified at this time. Additional incidental mortality studies should be undertaken coincident with the development of any new selective fishery methods or gear prior to widespread deployment. Accordingly, the approach to implementation of new RPA 167 studies will be to act opportunistically to new selective fishery proposals as they emerge, and to promote such studies through the co-managers, particularly for high-impact fisheries like the Zone 6 gill net fishery or selective mark recreational fisheries, including steelhead.

F. Data Management Workgroup Plan

(1) Executive Summary

The 2000 FCRPS Biological Opinion requires that the Action Agencies develop a common data management system for fish populations, water quality, and habitat data. This work plan describes the steps that the Action Agencies intend to take to meet the Opinion requirements.

The Opinion contains 199 Reasonable and Prudent RPA Actions, including about 100 Actions with a direct research, monitoring, or evaluation (RME) component. Most of these 100 Actions collect and analyze RME data at mainstem hydro projects. The remaining RME Actions (179 to 199) are concerned with the design and implementation of a research, monitoring, and evaluation (RME) program in the four major categories of actions: Habitat, Hydro, Hatchery/Harvest and Ocean/Estuary. In each of these action categories there are five major categories of RME data management: population status, environmental status, action effectiveness, critical uncertainties, and compliance.

The Action Agency data management work plan identified four areas of need for the implementation of Actions 179-199:

- A more comprehensive scoping of existing regional data management projects/goals/ needs

- A formal comparison of regional data management goals/needs compared to the FCRPS Opinion goals/needs

- The development of a FCRPS RME information system architecture or blueprint that is consistent with regional needs

- The development of an information system(s) from the ground up in a modular fashion so that the system(s) meets the practical needs of the local users while meeting the legal and administrative requirements of the region

These needs will be filled by: (1) participation in the development of a regional (common) data management system while providing real-time data management support for the research, monitoring, and evaluation Actions in the Opinion; and (2) implementation of a data management prototype for tributary habitat in the three subbasins that are proposed for status and effectiveness research monitoring. The work plan lays out a series of work tasks and associated schedules and costs.

Decisions to move forward on RME data management are urgently required. A high level of interagency coordination and cooperation will be necessary to develop successful prototypes and systemwide data management programs. Formal agreements may be required for cost sharing, data standards, and data sharing protocols.

IV. Appendices A-F Detailed RME Workgroup Plans

A. Appendix A: Population/Environmental Status Monitoring Workgroup Plan

(1) Introduction

The goal of population and environmental status monitoring as proposed under the NMFS 2000 Federal Columbia River Power System Biological Opinion is to provide the necessary data for resolving a wide range of uncertainties, determining population status, establishing the baseline for the causal relationships between habitat attributes and population response, and facilitating the assessment of the overall impact of management actions.

The FCRPS BiOp outlines a hierarchical comprehensive monitoring and evaluation program. The program consists of three levels of effort: (i) a broadscale assessment of ecosystem status, (ii) an annual sampling of the status of fish populations and their habitat, and (iii) the effectiveness of specific recovery actions. The first two components form the Population and Environmental Status Monitoring Program, while the third component is addressed in the AER monitoring program (fully specified in an additional section of this document). The status monitoring program for salmonid fishes and their habitat in the Columbia River basin is designed to address the following list of questions. Each of these questions is framed in a general fashion to allow for geographic, logistical, and biological constraints. For example, the spatial scale for many of the questions is either population, subbasin, or ESU, depending on the most appropriate or convenient scale at which to collect the required response variate. Policy and technical representatives of the management entities must first work together to specify both the level of acceptable risk (uncertainty) for making management decisions and the cost they are willing to bear for a monitoring program. Within those constraints, the accuracy and precision of all measurements must be specified in order to design the data collection scheme and to allow the development of confidence intervals for analyses based on these data.

Ecosystem status questions:

What is the distribution of adult salmonid fishes?

measured variate(s): presence/absence of adult salmonid fishes
spatial scale: Columbia River system, ESU
accuracy and precision: census
temporal scale: sampling on 3- to 5-year cycle

What is the ecosystem status for Columbia River Basin (CRB) fish populations?

measured variate(s): Geology/Soils, Land classification, Stream network, DEM, Road, Land ownership
spatial scale: Columbia River system, ESU
accuracy and precision: census
temporal scale: sampling on 5+-year cycle

Population and habitat status monitoring questions:

What is the size of CRB fish populations?

measured variate(s): numbers of adults, spawners or redds
spatial scale: population, sub basin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the annualized growth rate of CRB fish populations?
measured variate(s): numbers of adults, spawners or redds
spatial scale: population, sub basin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: trend in annual samples over at least 10-year period

What is the freshwater productivity (e.g., smolt/female) of CRB fish populations?
measured variate(s): index of juvenile population
spatial scale: population, subbasin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the age-structure of CRB fish populations?
measured variate(s): age of returning adults
spatial scale: population, subbasin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the fraction of potential natural spawners that are of hatchery origin?
measured variate(s): fraction of escapement that is of hatchery origin
spatial scale: population, subbasin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the biological condition of CRB fish spawning and rearing habitat?
measured variate(s): macroinvertebrate, amphibian, and fish assemblages
spatial scale: subbasin, watershed
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the chemical water quality in CRB fish spawning and rearing habitat?
measured variate(s): DO, pH, Conductivity, Nutrients, Solids, Pesticide and heavy metal concentration, temperature
spatial scale: subbasin, watershed
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the physical habitat condition of CRB fish spawning and rearing habitat?
measured variate(s): Channel Form, Valley Form, Valley Width Index, Geomorphic channel units, Channel Substrate, Canopy cover, Large woody debris, Riparian vegetation, Land use, Number of diversions or dams, Assessment of erosion processes, Channel modification, Instream flow
spatial scale: subbasin, watershed
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

(a) Status Monitoring RPA Action Items

There are several specific calls for the development of a status monitoring program in the FCRPS BiOp. In particular, Action Items 180 and 181 outline the scope and scale of a hierarchical monitoring program with two levels of status monitoring (Tier 1 and Tier 2). In addition, the status monitoring program is further developed in Appendix G. However, the RPAs 180 and 181, Appendix G, and the body of the FCRPS BiOp do not fully specify the details of a comprehensive status monitoring program such that an implementation plan can be readily developed. The purpose of this document is to specify many of the undefined aspects of the status monitoring program and outline an action plan for its further development. Aspects of the status monitoring program that are not fully specified in the BiOp include, but are not limited to: (1) the form of the landscape scale monitoring, (2) the statistical sampling framework of the habitat and population monitoring, (3) the indicators to be measured in both the habitat and population (4) landscape scale monitoring programs, and (5) the analytical framework for evaluating the data generated by the status monitoring program.

(b) Status Monitoring Performance Standards

The FCRPS BiOp uses Performance Standards as the metric by which implementation of the RPAs will be assessed. Performance standards for the RPAs derive from the biological requirements of the listed populations at the life-cycle and at each life stage. FCRPS BiOp performance standards are defined in three tiers. The most general tier is the population level performance standards. These standards define the performance needed for the listed population to achieve adequate likelihoods of survival and recovery. Life stage-specific performance standards at the intermediate tier allocate across the life cycle the performance expectations necessary to achieve the population-level standards. This tier guides the development of performance standards for categories of actions in habitat, harvest hatcheries, and hydropower. The third-tier standards are intended to achieve the life stage standards.

The FCRPS BiOp explicitly calls for particular biological indicators to be monitored in specifying tests that will be applied at the check-ins. At this level there are four specific population level check-ins requiring population numbers and productivity assessments (FCRPS BiOp, 9.2.2.1). Satisfying these check-in assessments arises directly from the status monitoring program.

In order to accomplish the required data collection and evaluation implied by the FCRPS BiOp life-cycle and life-stage performance standards, the status monitoring program itself requires standards of performance. These standards specify the design of the status monitoring program, for example the spatial and temporal resolution, as well as the acceptable levels of measurement and sampling error for each indicator. Ideally these design performance standards would be established by working back from data needs specified by FCRPS BiOp check-in assessments and other management decision points. However, the analytical approaches underlying the evaluation phase of the monitoring program are not fully established. Therefore, some of the performance standards advanced in the Action Plan are to be determined during pilot implementation of the status monitoring program, some are specified as commonly accepted values, while others are unknown prior to a complete assessment of the monitoring program.

Thus, the status monitoring program itself has a suite of performance standards, as well as being the critical component of the data collecting framework to generate performance standards for other RPA Action Items. The form of the performance standards, their definition, and the analytical tools for their generation are to be developed in concert with the implementation of the status monitoring program.

(c) Status Monitoring Action Plan Items

The Action Plan for the population and environmental status monitoring program of the FCRPS BiOp addresses the following items:

- Define the Status Monitoring component of the FCRPS RME program.
- Define the relationship of the Status Monitoring program to the other FCRPS RME components.
- Generate implementable guidance for a Status Monitoring program.
- Identify performance standards for the Status Monitoring program.
- Identify the degree to which status monitoring is currently being successfully implemented, including identifying the gaps in current work in terms of occurance/ non-occurance, as well as quality. Incomplete or inadequate monitoring programs need to be identified as gaps so that they may be improved or replaced as necessary to achieve a consistently adequate monitoring program.
- Identify the structure of handling, storing, and disseminating the data generated by the monitoring program so that appropriate evaluation can progress.
- Identify strategies for design of evaluation or decision making and planning tools.

(2) Performance Indicators and Standards

(a) Population Level Performance Standards

In accordance with 2000 FCRPS BIOP, the anadromous salmonid status monitoring program under the Action Agencies Implementation Plan must collect data to answer the following four questions at the 2005 and 2008 check-in evaluations. These questions constitute quantitative tests, and they are specified as requirements for assessing the status of ESA listed salmonid species in the Columbia River Basin (FCRPS BIOP, 9.2.2.1).

1. Is the annual population growth rate greater in 2005 and 2008 than during the base period (1980 - 2000)?
2. Is the annual population growth rate in 2005 and 2008 greater than or equal to the projected growth rate based on improvements from actions taken in the 1995 biological opinion, reductions in harvest that occurred after 2000, and the survival standards in the Mid-Columbia Habitat Conservation Plan?
3. Is the projected annual population growth rate in 2005 and 2008 (based on best available information about the expected effects of hydro and offsite mitigation actions and other regional actions under the All-H strategy) equal to or greater than the growth rates believed necessary to achieve the 48-year recovery criteria?
4. Is the annual adult return of wild fish as represented by the 5-year geometric mean for each ESU and population greater than the ESU and population size (5-year geometric mean) in 2000?

To address these standards, the Actions Agencies must measure and document the change in population status by monitoring adult abundance. This requires enumerating (census of all adults) or estimating via a statistically rigorous sampling program, adult abundance on an annual basis. What is unclear at present is the scale (population/subbasin/ESU) and precision (+/- 10 percent, 20 percent, 30 percent) of the monitoring for each listed species. The NMFS-Action Agency RME group will make recommendations for these aspects of the monitoring program design, but cannot alone set these standards.

(b) Environmental and Physical Performance Standards

Except for the Hydro-corridor, the BIOP only generally describes the types of performance standards that may be derived for Habitat and Hatchery areas. For the Hydro-corridor, the standards take the form of flow targets and spill and transportation schedules intended to maximize smolt survival. The BIOP leaves the door open for the community to specify more tangible performance standards. In terms of developing specific sets of habitat and environmental indicators for the three geographic zones, the BIOP offers little guidance. This is another area the Action Agencies/NMFS RME team has been attempting to solidify.

Indicators (Performance Measures) Linked to Performance Standards

Using the BIOP Performance Standards as a foundation, the RME Team has designated the following classes of performance measures as the foundation of the Status Monitoring. An "E" indicates an essential need to acquire the information. These are essential for meeting the Action Agencies' obligations to track progress toward recovery. An "s" indicates useful, but supplemental information not explicitly required to meet BIOP-specified performance standards. A "?" indicates that the information is desirable, but the means to obtain representative and useful estimates is unclear. For example, in tributaries juvenile salmonids can disperse or migrate during different times of the year at various life stages; how, when, and where to monitor a life stage(s) to represent population productivity may be difficult to determine. As another example, it is not clear how to estimate juvenile and adult survival in the estuary/nearshore zone. At this juncture, this table represents an initial prioritization roadmap for FCRPS BIOP status monitoring.

Status Monitoring - classes of indicators/performance measures

Monitoring Zones	Abundance		Survival		Environmental conditions
	Juveniles	Adults	Juveniles	Adults	
Tributaries	E	E			E
Hydrosystem	s	E	E	E	E
Estuary			?	?	s

(c) Population-Based Indicators – Tributaries and Hydrosystem

To determine changes in population growth rate and abundance, spawner escapement and removals must to be estimated. Removals may be caused by passage mortality or in-river harvest. Different species offer different opportunities for estimating spawner escapement. For example, redds counts have generally been adopted as acceptable for tributary spawning chinook. In contrast, steelhead redds can be difficult to observe during spawning periods when flows are high, thus other enumeration techniques may be required. For mainstem spawning species like fall chinook, deep water redds are difficult to identify, so dam counts must usually suffice.

Defining the goals of the proposed monitoring effort is a fundamental first step. To initially define performance measures, the RME team has used the data requirements of the analytical process that uses the monitoring data. For example, the life cycle analyses employed in the

BIOP require annual estimates of age composition and sex ratio for the returning adults. In compiling this list of candidate performance measures, we did not restrict data needs to BIOP driven analyses, but attempt to satisfy broader applications as well. Furthermore, the RME Team recognized those future models for population viability and other BIOP applications may change, requiring additional data (e.g., annual age structure).

Candidate fish population indicators/performance measures are:

Adult Life Stage –

1. Adult counts: weir or dam counts
2. Spawners: carcass or redd counts
3. Removals by fisheries or passage mortality
4. Hatchery fraction of natural spawning fish: hatchery marks
5. Sex ratio of spawners or adults: carcass surveys or traps
6. Age structure: scale or length analysis

Juvenile Life Stage –

1. Abundance estimates at strategic locations

The enumeration or estimation of spawner abundance is required to conduct the BIOP-specified performance standard tests. Estimates of juvenile abundance are not explicitly required under the BIOP, but are necessary to generate estimates of survival, SARs, and as population status indices. Opportunities to obtain useful juvenile indicators will vary by ESU. For example, Snake River fall chinook are particularly problematic. They migrate throughout the year in the mainstem, including periods when sampling devices are inactive. However, whenever possible, juvenile abundance should be estimated for populations/ESUs.

Other Status Monitoring Needs and Programs

Collectively the indicators identified herein are the key elements comprising the Status Monitoring component of Action Agencies FCRPS RME Program. However, there are other regional monitoring programs that need the same data, and additional information beyond the scope of the Action Agencies Plan. Those other regional monitoring programs were briefly discussed in Section 1.0 of this document.

The need for, and benefits of, a systematic, integrated, regional status monitoring program is recognized by a broad spectrum of federal, state, and tribal fish and wildlife recovery and restoration plans (NMFS 2000a, NMFS 2000b, CRITFC 1995, Roger *et al. 2000*). Despite this common goal, actual implementation of a cohesive status monitoring program has proven to be elusive. Obstacles are evident in the form of policy, technical, and on-the-ground challenges including:

1. Policy Challenges

    - There is an unspecified level of uncertainty that is acceptable for decision making.

- Cooperation of necessary private, local, state, tribal, and federal jurisdictions is difficult to achieve.
- Agencies have different scopes of responsibility and authority.
- Agencies often have no mandate for supporting regional programs.
- Different entities and programs operate at different spatial and temporal scales.
- There is a perceived high cost.
- There is insufficient technical feedback to policy makers.

2. Technical Challenges

- There is no comprehensive catalog of existing monitoring efforts.
- No concise, clearly described basinwide monitoring program presently exists.
- Specific monitoring responsibilities need to be assigned to, and accepted by a complex of agencies.
- Data management technology is evolving rapidly and the various entities are at different stages of ability and have different levels of available resources.

3. On-the-Ground Challenges

- Coordinating field crews from multiple agencies is operationally difficult.
- Field crews often do not have time for data entry and QA/QC activities.
- An agreed upon manual describing field data collection methods is needed to guide diverse field crews.

There is much work to be done in this regard, which will involve the participation of many agencies besides the Action Agencies and NMFS. A common vision and full participation by all affected agencies is required. NMFS and the Action Agencies cannot develop a regional plan on their own, nor would it be appropriate, but they can focus on particular issues in the context of the FCRPS BIOP. One concern is that a standard set of guidelines or procedures for collecting monitoring information has not yet been established. This is necessary to ensure that compatible data are collected by different agencies, and the quality of that data is sufficient to satisfy the check-in tests envisioned by NMFS.

Herein NMFS and the Action Agencies propose preliminary guidelines for establishing sound protocols for collecting status monitoring data. The focus here is on biological indicators linked directly to listed salmonid ESUs. With respect to environmental indicators, NMFS and the Action Agencies rely on established environmental monitoring programs to develop appropriate methods for application in the tributary and estuary zones, as well as at the ecosystem/landscape level.

(3) Status Monitoring Programmatic Needs Assessment

(a) Guidelines for the implementation of status monitoring - FCRPS BIOP Focus

The following sections briefly outline the proposed guidelines for implementation of a status monitoring program targeting salmonid ESUs listed under the ESA. They may also have broader application for resident fish populations and their habitats. The Action Agencies and NMFS suggest that if the guidelines are implemented, the status monitoring program will likely meet the needs of the BIOP and may satisfy broader regional goals.

Ecosystem Level Status Monitoring

Much of the critical data for assessing ecosystem status should be collected at a watershed to sub-basin scale. There are two classes of landscape-level ecosystem attributes: salmonid species presence/absence and environmental/habitat conditions. Both fish and environmental data should be compiled and reported every 5 to 10 years, although sampling may occur in more frequent time-steps.

Tasks will include:

1. The acquisition and digitizing of aerial or satellite imagery of the entire Columbia River Basin, for key landscape attributes.

2. Survey the presence/absence of adult anadromous salmonids to document range expansion or contraction.

Landscape-level data collection will allow a more detailed assessment of land use and land cover variables than is currently available. This assessment, in turn, will allow the association of potentially important watershed-level characteristics with salmon population status. In addition, repeated collection and assessment of the variables through time will allow analysts to assess if changes in environmental characteristics are associated with changes in salmonid population status. These data will have value for resource and wildlife management well beyond listed salmon species.

Guidelines – Ecosystem status indicators

1. Clearly identify the appropriate geographic scales (e.g., subbasin, watershed) and resolution (e.g., 1:24k, 4m pixels) at which the status indicators are measured.

2. Identify the indicators that will be directly measured (e.g., fish presence/absence, DEM) to estimate ecosystem status.

3. Describe the method used for determining derived indicators (land classification, stream network).

4. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating indicator values.

The Action Agencies and NMFS rely on federal land use agencies and state agencies to identify a set of key environmental/habitat indicators that should be monitored, although we offer some suggestions including geology/soils, land classification, stream network, DEM, roads, passage barriers, and land ownership. The Pacific Northwest Ecosystem Research Consortium has described sampling methods and associated precision estimates for these indicators. This may provide a model for a broader regional program.

Geographic Zone Status Monitoring – Population Status Monitoring-Adults

In order to track the status of a population, spawner escapement and removals en route to the spawning ground must to be estimated. Removals may be caused by passage mortality or in-river harvest. Different species offer different opportunities for estimating spawner escapement. In the Columbia River Basin, redds counts have generally been adopted as acceptable for tributary spawning chinook. In contrast, steelhead redds are difficult to observe during spawning periods when flows are high, and are not particularly useful for estimating escapement using traditional peak count methods. However, new methods recently developed by the Oregon Department of Fish and Wildlife Corvallis Research Lab indicate that cumulative steelhead redd counts may be a very reliable method for estimating adult steelhead abundance (Jacobs et al. 2001). For mainstem spawning species like fall chinook, counting redds in large, deep rivers is not very reliable, so dam counts usually must suffice. Recent work by the USFS Rocky Mountain Research Lab has begun to address the measurement error associated with a variety of types of redd count methods (Dunham et al. 2001, Thurow 2000).

Guidelines – Population Status - Adult Life Stage

1. Clearly identify the demographic scale (e.g., population, ESU, deme; wild/natural or hatchery origin) for which abundance estimates will be produced.

2. Demonstrate that the target unit is readily distinguishable from other sympatric population units (e.g., spawning location, timing, etc.).

3. Identify the performance measure or indicator that will be monitored/enumerated (e.g., redds, carcasses, weir counts, dam counts, etc.) in order to estimate spawner escapement. If multiple methods (e.g., weir counts and redd counts) are used to enumerate the same population, specify.

4. Describe the method used to enumerate the indices, e.g., aerial or ground surveys, peak or cumulative (repeated) counts, and the error associated with the method.

5. Specify any expansion factors (e.g., spawners/redd, expansions beyond index areas) or other adjustments (e.g., harvest removals, passage mortality) that need to be applied to the raw counts. Provide the rationale supporting the use of those expansion factors, how the factors change over time, how they are estimated, and assess their reliability.

6. Provide estimates of the annual age structure of the sampled population and how this is estimated.

7. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating spawner escapement, or total numbers of returning adults.

Here we propose precision targets (Coefficient of Variation: CV = 100 x standard deviation/ mean) associated with key indicators to be CV < 15 percent, unless noted otherwise. All data needs to identify precision. It is assumed that estimates are unbiased, and monitoring groups can verify this empirically. Data will be collected on an annual basis at the subbasin scale:

- Adults, Spawners, or Redds
- Age structure of spawning population

- Sex ratio of spawning population
- Fraction of naturally spawning fish that are of hatchery origin, CV < 10 percent.

Recent work by ODFW 2001 and Jacobs and Nickelson (1998) suggest protocols and sampling methods that may provide satisfactory precision for the above indicators.

Population Status Monitoring – Juveniles

The abundance of juvenile salmonids in tributary habitats can be a useful indicator of population productivity. Some measure of juvenile production for each listed ESU would be advantageous, however information in selective subbasins may have to suffice. The juvenile component of the status monitoring program seeks to generate, at a minimum, a trend in the juvenile production index at the subbasin scale, but when possible should generate the status of the juvenile population by demographic unit. In most cases, population size estimates will be based on sampling by trap, snorkeling, or mark recapture. Often such estimates are so coarse they are characterized as general indices. Depending on the life stage of interest (fry, parr, smolt), sampling opportunities vary.

Guidelines – Population Status - Juvenile Life Stage

1. Clearly identify the demographic unit (e.g., population, ESU, deme; wild/natural or hatchery origin) over which sampling will take place.

2. Clearly identify the spatial scale represented by each sample (e.g., reach, watershed, basin).

3. Identify the performance measure or indicator that will be monitored (e.g., summer/ winter juveniles, outmigrating smolts). If different methods are used to enumerate the same population, specify.

4. Describe the method used for enumerating the indices, e.g., snorkel surveys, electro-fishing, smolt trap, and the error associated with the method.

5. Specify any expansion factors (e.g., aerial expansions, trap efficiency) or other adjustments (e.g., daylight trapping only) that need to be applied to the raw counts. Provide the rationale supporting the use of those expansion factors, how the factors change over time, how they are estimated, and assess their reliability.

6. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating juvenile abundance or an index of juvenile abundance.

Here we propose precision targets (CV < 15 percent) associated with key indicators. It is assumed that estimates are unbiased. Data will be collected on an annual basis at the subbasin scale:

- Estimate abundance of in-stream juveniles
- Estimate out-migrating juveniles
- Age/size classes of sampled juveniles
- Condition of sampled juveniles

A recent work by Rodgers (2001) and previous papers by Hankin and Reeves (1984, 1988) suggest protocols for sampling methods that provide satisfactory precision for the above indicators.

Habitat Status Monitoring

The goal of habitat or environmental status monitoring is to quantify and characterize the condition of habitat occupied by listed anadromous salmonids at the appropriate geographic scales. Information derived from these analyses may be useful in describing the current environmental conditions that support native salmonids and in developing associations with populations trends. The responsibility for monitoring environmental conditions in the hydro-corridor is clearly the responsibility of the Action Agencies. The responsibility for environmental/habitat monitoring in the tributary and estuarine zone will be jointly shared with established programs like EMAP, PACFISH/INFISH, the OR Plan, WA Plan (SSHIAP), and the Lower Columbia River Estuary Plan. Guidelines proposed here are generic and may be appropriate for all applications.

Guidelines – Environmental/Habitat Status Monitoring –

1. Clearly identify the appropriate geographic scales (e.g., province, ecoregion, subbasin, etc.) for sampling.

2. Identify the indicators that will be monitored (e.g., land cover, habitat types, stream temperature, summer base flow, etc.).

3. Describe the protocol for measuring or estimating each indicator.

4. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating indicator values.

5. Describe the known or probable relationships between environmental attributes and salmonid productivity.

6. What is the status of environmental attributes potentially affecting salmonid populations?

7. How do these attributes change through time?

8. Assess the associations between environmental attributes and salmonid population status.

Here we identify candidate indicators and suggested precision (CV) for attributes at the subbasin scale for annual estimates. All estimates must be unbiased. The following list may be changed (expanded/contracted) as the program is developed further.

Biological Condition

- Macroinvertebrate assemblage, CV < 15 percent
- Fish and amphibian assemblage, CV < 15 percent

Chemical Water Quality

- Dissolved oxygen, CV < 15 percent
- pH, CV < 15 percent

- Conductivity, CV < 15 percent
- Nutrients (N and P), CV < 15 percent
- Solids, CV < 15 percent
- Pesticide and heavy metal contamination, CV < 15 percent
- Stream temperature, CV < 15 percent

Physical Habitat (CV < 25 percent)

- Channel Form
- Valley Form
- Valley Width
- Geomorphic channel
- Channel Substrate
- Canopy cover
- Large woody debris
- Riparian vegetation
- Land use
- Number of diversions or dams
- Qualitative or quantitative assessment of erosion processes
- Channel modification
- Instream flow

References describing protocols for sampling methods that provide the desired precision include:
Kaufmann P.R. et al. 1999, Thom, B.A. et al. 1999.
ODFW Habitat sampling protocol manuals: Jones & Moore 1999, Moore et al. 1998.
ODEQ Habitat sampling protocol manuals/reports: Oregon Plan 1999, Hubler 2000, Drake 1999, Canale 1998.

Statistically based sampling design for status monitoring

For the systemwide status monitoring program to be both accurate and cost-effective, data must be gathered using a rigorous, unbiased sampling design. Sampling designs for spatially explicit data such as habitat surveys are quite complex. The sampling scheme must provide information on the status and trends in abundance, geographic distribution, and productivity of listed anadromous salmonid populations and their habitat at the population to subbasin scale. The sampling design must estimate these quantities with no bias and known precision. The primary concern is selecting sites across a large spatial area without inflating the variance or biasing the estimate. The traditional sampling approach, simple random samples, has the potential to inflate variance and bias the estimators because the samples can end up clumped in space. The next generation of sampling schemes, stratified random sampling, addresses the spatial distribution of sites if the strata are themselves evenly distributed, but has the potential to introduce hidden biases if the strata are not correctly chosen. In addition, stratification always requires more samples to maintain power across strata. For landscape-scale sampling the ideal system has built-in spatial distribution—sampling on a grid rather than randomly across space.

For grid-based sampling, the question becomes one of grid shape and site selection. Randomly selected points on the grid will generate the least biased estimators, but can suffer the same problem as simple random samples if the grid units are too small relative to the area of interest.

There are many grid-based site selection techniques that provide probabilistic samples that generate unbiased estimates of status and trend. The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) is an example of a spatially balanced environmental monitoring site selection process especially designed for aquatic systems. The state of Oregon has successfully implemented an EMAP-based sampling program for coastal coho salmon (Moore 2002). The monitoring program as implemented in Oregon is spatially explicit, unbiased, and has reasonably high power for detecting trends. The sample design is sufficiently flexible to use on the scale of multiple large river basins and can be used to estimate the numbers of adult salmon returning each year, the distribution and rearing density of juvenile salmon, productivity and relative condition of stream biota, and freshwater habitat conditions. In addition, the EMAP site selection approach supports sampling at varying spatial extents. All grids are interpenetrating so that a lower density grid is a subset of all higher density grids.

General description of current projects and programs addressing these needs
At the ecosystem scale, there have been several comprehensive one-time data collection efforts. For example, NWPPC Subbasin Assessments require the compilation of some, but not all, data layers recommended by the FCRPS BiOp status monitoring program. In addition, the Interior Columbia Ecosystem Management Project (USFS/BLM) has assembled a large collection of spatial data layers highly relevant to ecosystem scale status monitoring. However, both of these assessments are not meant to be ongoing and periodic; rather they are one-time data gathering efforts to support long-term land use and management planning. As such, they potentially can form the first round of ecosystem scale status monitoring data collection, but an ongoing program would need to be established. A plan for implementing status monitoring at this scale is presented in the following section.

At the subbasin scale, there are numerous state and tribal annual sampling programs targeting salmonid fishes, and to some extent their habitat, distributed across the Columbia River basin. For a summary of these programs see the attached spreadsheet (SM_Action_Plan_Table.xls – 1. – 6.) of the status of status monitoring programs. While there are a large number of status monitoring programs currently underway in the Columbia River basin, there is little coordination of these programs across administrative boundaries, and as such, the resulting status monitoring data may not be adequate to address regional, or basinwide management needs. The subbasin scale status monitoring program outlined in this document was generated to meet the basinwide management needs in that it attempts to unify the approaches to the monitoring of status and trends of salmonid populations and their tributary habitat environment. The plan to implement such a status monitoring program is presented in the following section; in particular, the staged implementation of pilot projects, and the mechanisms by which a large scale cooperative program could be developed by building on existing status monitoring programs.

Assessing the gaps between FCRPS BiOp status monitoring program guidelines and currently existing programs
A critical first step in the FCRPS BiOp status monitoring program development is a more thorough assessment of the gaps that exist between the proposed status monitoring program and the myriad currently implemented status monitoring programs. To this end, a draft survey instrument has been developed that could inform the gaps assessment effort (SM_Action_Plan_Table.xls – 8). A gaps assessment would necessarily have three components:

(i) a compilation of existing programs, (ii) an alignment stage whereby the list developed in (i) is compared to the FCRPS BiOp status monitoring guidelines, and (iii) an assessment of the actual and functional differences. Tasks (i) and (ii) are relatively straightforward data collection and organization efforts; however, task (iii) requires a complete working knowledge of the FCRPS BiOp status monitoring program's intention, as well as that of each existing status monitoring program that appears to match the BiOp guidelines. That is to say, due to differing programmatic intents, existing status monitoring programs may appear to directly meet aspects of the FCRPS BiOp status monitoring program's needs, yet be functionally so different that almost no overlap actually exists. For example, if the spatial or temporal resolution of indicators and protocols differ substantially between two monitoring programs, the information, while similar in name, is not mutually useable. In general, sampling done at a coarser spatio-temporal scale than specified by the FCRPS BiOp status monitoring program will not be of direct utility. However, if on the scale of individual samples, the field protocols are similar, and the statistical basis for sampling in both cases allows for sampling schemes at multiple scales (e.g., the interpenetrating grids of EPA's EMAP designs), then coarse scale sampling can form part of a finer scale sampling program. While such a situation would be an ideal compromise between multiple programs with independent, seemingly mutually exclusive objectives, the coordination required for implementation and subsequent data analysis would be considerable.

(4) Action Plans for meeting RME Needs

A well-designed monitoring and evaluation program is a critical component of any conservation or restoration activity. Monitoring is vital in determining whether specific management actions have been effective, and large-scale monitoring and evaluation is important in assessing the success of integrated actions having achieved desired population size, distribution and trends. Moreover, well-coordinated management actions, when coupled with relevant monitoring and evaluation programs, can reduce uncertainty about the effect of those actions on population productivity.

The primary goal of this monitoring and evaluation effort is to design and implement a system of statistically rigorous data collection schemes to answer questions fundamental to the management and recovery of anadromous salmonids. In spite of tremendous past efforts many of the most important questions remain unanswered due to basic uncertainties in these fishes' population processes, both with respect to trends in abundance as well as the factors that regulate salmonid population dynamics.

At present there are a number of high-quality population and habitat monitoring and assessment programs within the Columbia River Basin (e.g., Oregon Plan 1997; Alverts *et al.* 1997, CBFWA 2001). However, none of these programs has both comprehensive geographic coverage and a sampling theoretic basis. In particular, there are no comprehensive guidelines to be drawn from these plans that can be used as a template for monitoring the status and recovery of impacted populations as well as their breeding, rearing, and migratory corridor habitat in the entire Columbia River Basin. At issue is both the type of data traditionally collected to assess population and habitat status, and the manner by which the data collection scheme is implemented in time and space.

Thus the primary objective of this status monitoring action plan for the Columbia River basin is a statistically sound sampling design that when implemented will generate useful data with known analytical and predictive power. Several technical challenges are immediately apparent, and this work is distinct from previous efforts in how it will approach these challenges. The primary complication arises from the enormous spatial scale and resulting heterogeneity of the sampling areas and indicators. As such, the manner of population and habitat sampling, and the manner in which the samples are distributed in time and space, will strongly influence the assessment of status and effectiveness. To satisfy this constraint requires considerable knowledge of both the spatial extent of true demographic units and the mechanisms of population regulation, potentially more than is currently known. However, lacking these key pieces of information does not mean that we are unable to accurately assess population and habitat status, but it does mean that we must do so under a modern and statistically rigorous sampling program informed by our knowledge of demographic and habitat processes. This plan presented here is intended to develop and test status and trend monitoring approaches capable of the statistical rigor specifically required by the region's natural resource management agencies and personnel.

(a) Action Plan for Implementation of Status Monitoring Program

A FCRPS BiOp motivated status monitoring program for anadromous salmonid populations and their habitat at both the ecosystem and subbasin scale will be implemented in a step-wise fashion guided by the following components: a comprehensive gaps analysis of ecosystem and subbasin scale status monitoring programs; subbasin scale pilot projects; coordination with federal, state, and tribal monitoring programs; and coordination with the recovery planning efforts of the Lower Columbia/Willamette and Interior Columbia Technical Recovery Teams.

Gaps Analysis

The first step in the development of a basinwide status monitoring program is the comprehensive assessment of current programs, their ability to meet regional performance standards, and the resulting programmatic gaps. For the status monitoring program in general, and the subbasin scale pilot projects in particular, a targeted gaps assessment should be immediately undertaken. The ecosystem and subbasin scale status monitoring program performance standards and requirements are presented here as defined by the needs of the NMFS 2000 FCRPS BiOp. Therefore, the next step, a compilation of current status monitoring efforts, can be initiated. Ultimately, the gaps between needs and current programs can be modified as the regional needs for a status monitoring program are better defined, but these discussions will in no way interfere with the assessment of current efforts.

Pilot Studies

The initial phase of basinwide implementation of a FCRPS BiOp motivated status monitoring program will be subbasin scale pilot programs: an assessment of ecosystem scale status monitoring approaches based on remote sensing data in the John Day and upper Salmon River basins; and status and trend monitoring efforts for anadromous salmonids and their habitat in the Wenatchee, John Day and upper Salmon River basins. The ecosystem scale status monitoring project is designed to directly assess the utility of large scale remote sensing data collection (i.e., as specified by RPA 181). The subbasin scale status monitoring pilot project builds on current status and trend monitoring programs being developed in the Oregon portion of the Columbia Plateau (e.g., BPA/CBFWA proposals 25088, 25010) by extending the pilot program development process to subbasins in Washington and Idaho. In both cases, the pilot studies differ from much of the ongoing ecosystem and subbasin scale status and trend monitoring in the Columbia River basin as it focuses on the explicit development and testing of the protocols and methodologies required for generating ecosystem, habitat and population monitoring data of known spatio-temporal resolution, accuracy and precision.

Ecosystem scale
Given the enormous area over which Pacific salmonids interact with their environs, the task of measuring habitat quality and quantity becomes problematic. Local scale habitat linkages are fairly well understood; however, broad scale landscape habitat linkages are poorly understood. While there are clear patterns in the correlations between land use and land cover at a landscape scale and salmonid population trajectories, these correlations are often too general for extrapolating mechanistic connections between habitat type and condition, and salmon population status. This inability to make mechanistic connections is a result of two limitations. First, most studies that attempt to relate gross habitat attributes with population trends, use static geospatial data layers. Clearly, a time series of land use and land cover change is a better choice if we wish to correlate habitat conditions over time with salmon population trends. Second, to date, there has never been a classification of remote sensed imagery that was specific to Pacific salmonid habitat requirements. Therefore, pilot projects to explicitly address these two major limitations to the potential utility of ecosystem scale status monitoring programs need to be initiated.

Pilot projects will be supported by previously acquired satellite imagery, and will be most useful if coordinated with subbasin scale habitat and population monitoring pilots for data sharing and ground truthing. Specifically, the pilot projects must each address the following list of issues.

Change detection:
- Is it feasible to use change detection on LANDSAT TM remote sensed data, in particular for the following land use land cover classes: Agriculture, Urban, Logging, Riparian vegetation, Wetland vegetation, Roads?
- Does a time series of land use and land cover improve the fit of fish habitat models?
- Can riparian and wetland habitats be classified accurately using LADNSAT TM remote sensed data?

The project area is six subbasins within the Columbia River basin: Grande Ronde (OR), John Day (OR), Salmon (ID), Wenatchee (WA), Willamette (OR), and Yakima (WA). The project will be based on an existing time series (1984, 1988, 1992, 1996, and 2000) of raw LANDSAT TM imagery. It is recommended that this project build upon existing efforts to classify land use and land cover in the United States, such as U.S. Geological Survey (USGS) National Land Cover Database, USGS Land Use and Land Cover Program, National GAP Analysis Program, and the Northwest Habitat Institute Current and Historic Wildlife-Habitat Types Program.

Practicality of ecosystem monitoring via remote sense data:
- How much of field or ground surveyed information can be gathered using remote sensed data?
- What are the limitations of various remote sensed data layers with respect to habitat feature delineation?
- How much of he remote sensed imagery classification process can be automated?
- Can remote sensed data of different spatial and spectral resolutions be used in combination to generate high spatial resolution habitat classifications?

- Can pattern recognition or texture analysis be used to enhance classification of high spatial resolution/low spectral resolution remote sensed data?

The project area is the Upper Salmon River within the Salmon River basin, Idaho. The project will be based on existing raw LANDSAT TM images, as well as IKONOS 1 m panchromatic and 4 m multispectral images. The final product should be a geospatial data layer containing the various land use and land cover categories, with particular focus on the following habitat attributes or features:

- Logging extents
- Riparian vegetation
- Wetland vegetation
- Roads
- Push-up dams
- Salmon redds or nests
- In stream habitat variables
- Pools, riffles, glides, etc.
- Stream channel width
- Log jams and large woody debris
- Substrate type
- Channel incision (as a result of loss of beaver habitat, grazing [trampling, compaction, and devegetation], and climate change)

Subbasin scale

The status and trend monitoring program for anadromous salmonids and habitat in the Wenatchee, John Day and upper Salmon River basins will serve three major data collection efforts:

- At the scale of a subbasin, assess on an annual basis the status of adult populations of anadromous salmonids.
- At the scale of a subbasin, assess on an annual basis the population status or productivity of juvenile anadromous salmonids.
- At the scale of a subbasin, assess on an annual basis the status of salmonid habitat.

Data from the status and trend monitoring program will be used for a variety of resource management purposes. The primary utility of the information will be the annual assessment of status and resulting trend over time for these fishes and their habitat. However, this program will also support restoration action planning and assessment by serving as the baseline information used for action siting, and the baseline against which actions' biological impact could be measured.

The following outline describes the basic process for developing a subbasin scale status and trend monitoring program for anadromous salmonids and their habitat. This monitoring program's development is meant to pilot the development of a comprehensive monitoring program for the entire Columbia River basin. As such, the primary focus of this work is on the development and testing of the approach. Therefore, during program assessment and evaluation, addressing questions of how the pilot programs will scale up to cover a larger spatial extent will be critical.

The monitoring program development will be piloted in the Wenatchee, John Day, and upper Salmon River basins (wadeable portions of the subbasins; above Tumwater canyon in the Wenatchee, upstream from Kimberly in the John Day, and above the confluence of the Pahsimeroi in the Salmon), targeting natural spawning and rearing of steelhead (*O. mykiss*) and spring chinook (*O. tshawytscha*). The spatial extent of the monitoring program is limited by two major considerations, firstly the protocols being tested are specifically designed for wadeable streams, and secondly, as pilot programs the focus is on testing and development, rather than complete basin-wide coverage. In addition, by restricting the program's extent to portions of these three major drainages, each subbasin will be considered to consist of four major watersheds (Wenatchee: Nason, White, Little Wenatchee, Chiwawa; John Day: North Fork, Middle Fork, South Fork and Upper; upper Salmon: East Fork, Yankee Fork, Stanley basin, Challis basin). The division of the subbasins into major watersheds is based roughly on population structure information being developed by the Interior Columbia River Technical Recovery Team (Pers. Comm. M. McClure), and will be used primarily for organizational purposes, as well as for post-hoc stratification of data to address issues of monitoring program scale and status and trend analyses as a function of land management practices.

There have been numerous recent administrative and scientific calls for a comprehensive monitoring and evaluation program to provide consistent, region-wide information about the status of salmon populations and their response to management actions (Botkin *et al.* 2000, ISAB 2001, RSRP 2001). In addition, the 2000 Biological Opinion on the Federal Columbia River Power System requires the development and implementation of a coordinated monitoring and evaluation program (NMFS 2000a). The call for developing a consistent, regionwide monitoring program has been strong and widespread because once implemented, such a program will address a number of outstanding scientific agendas. First, it will provide a scientifically robust method to evaluate the status of populations and ESUs, and thereby gauge progress toward recovery goals, such as the delisting criteria defined by the regional TRTs (NMFS 2000b). Second, it provides the means to develop and refine appropriate performance measures and standards for conservation actions. Finally, it will provide managers with the tools to assess quantitatively the impact of single or composite actions on fish populations, thereby increasing our ability to conduct effective recovery planning.

The pilot status and trend monitoring program will address not only these scientifically-based policy agendas, but will also provide the framework in which to address a substantive administrative issue – implementing the requirements for developing the monitoring and evaluation program outlined in the NMFS 2000 Biological Opinion on the Federal Columbia River Power System (Actions 180-184, 188, 190, 191, 193, and 195-7), specifically, population and habitat status monitoring for anadromouns salmonids as required under Action Item 180.

Coordination with natural resource co-managers

The status monitoring program development as proposed herein will require extensive collaborative work with ongoing research and monitoring programs. The ecosystem scale pilot projects will require extensive collaboration with regional data management entities, as well as a wide range of resource management agencies currently doing landscape assessments (e.g., States, USGS, USFS/BLM) and research units developing novel approaches and techniques (e.g., OSU, PNWERC). For the subbasin scale status and trend monitoring pilot projects, the design and testing phase for this project will require collaboration with U.S. Environmental Protection

Agency research staff for statistical components of the design, and subbasin planning entities for programmatic components of the design. Implementation of the status and trend monitoring program will require extensive coordination with local co-manager groups in each subbasin. For example, in the Wenatchee River basin the pilot project will interface directly with the following ongoing efforts: U.S. Forest Service's Aquatic Habitat survey program, Chelan County PUD's juvenile salmonid sampling program, Washington Department of F&W's juvenile and adult salmonid sampling program, and Washington Department of Ecology's Regional Environmental Monitoring and Assessment Program. Similarly in the other subbasins, local coordination is key to the design, testing, and implementation of this program. At the regional scale, the pilot projects must be coordinated with basinwide recovery planning, regional development of monitoring strategies, and the implementation of a basinwide data management system. Overarching coordination groups such as CBFWA, Federal Caucus, and the ISRP could play a major role in setting the regional context for the status monitoring pilot projects.

Coordination with Technical Recovery Teams

The Technical Recovery Teams (TRTs) are charged with establishing demographic unit delineations, identifying factors for decline, and viability criteria for all populations of listed anadromous salmonids within their recovery domains. Two recovery domains overlap with the ESUs covered by the NMFS FCRPS BiOp. Therefore, the status monitoring program generated by the FCRPS BiOp RPA Action Items must support the efforts of the Interior Columbia and Lower Columbia/Willamette TRT with respect to the following ESUs: Snake River steelhead, Snake River Fall chinook, Snake River Spring/Summer Chinook, Snake River sockeye, Mid-Columbia River steelhead, Upper Columbia River steelhead, Upper Columbia River Spring Chinook, and Columbia River chum. The pilot status monitoring projects outlined above support the development of a status monitoring program that would address many of the TRT's requirements for all ESUs above, except Snake River sockeye, Snake River Fall Chinook, and Columbia River chum. These ESU's monitoring needs may be met through other programs (SR sockeye are primarily a captive breeding population, CR chum are currently monitored by USFWS and WDFW, and SR Fall chinook are monitored by IDFG and FPC); however a targeted assessment of these projects must be done in conjunction with the TRT's data requirements.

Based on draft population delineations, factors for decline and viability criteria, the Columbia River basin TRTs point to several major short comings in the region's status monitoring data collection program. In particular, the Columbia River basin lacks any systematic tributary habitat survey work that is linked to assessments of aquatic habitat condition. Several other major data gaps have emerged from the TRTs' work to date: a comprehensive assessment of the fraction of naturally spawning fish of hatchery origin, a comprehensive assessment of the utilization of mainstem habitat by steelhead, more complete population assessments of steelhead in general, and better monitoring of natural juvenile fish production and movement at the tributary level. Therefore, the FCRPS BiOp status monitoring program should explicitly address these issues to better support regional scale recovery planning.

Additional programmatic needs arising from non-status monitoring aspects of the NMFS FCRPS BiOp RME program

These additional programmatic requirements of the status monitoring program arise directly from status monitoring like components of the action plan for implementation of RME RPAs other than 180 and 181, as well as from the indirect needs of the status monitoring program. At present there are three major classes of these interactions.

Coordination with the Action Effectiveness Research efforts (RPA 183)
The subbasin scale status monitoring pilot projects will be directly coordinated with the AER projects in at least four ways. The AER and status monitoring programs have many biological and physical indicators in common. Therefore, the particular form of indicators, and in particular, specific protocol requirements, will be developed cooperatively between the status monitoring and AER programs. Since the status and trend components of the subbasin scale status monitoring program are relevant to the AER projects, status samples are similar to AER treatment samples, and trend samples are similar to AER control samples; therefore, the structure of rotating panel like sampling designs for the status monitoring program should be developed with the intent to be as directly applicable to the AER program as possible. Finally, direct interaction between the AER program and the status monitoring pilot projects will occur in the three pilot project subbasins. In these three locations, pilot scale implementation of both monitoring programs will be attempted.

Coordination with the Hatchery/Harvest RME efforts (RPA 182)
The implementation plan for RPA 182 identifies two major components of required work: an assessment of the breeding efficacy of individual hatchery origin fish spawning in the wild, and the spatial and numerical extent to which this occurs. The Hatchery/Harvest RPA Action Plan addresses the first component of the implementation of RPA 182, leaving the issue of the assessment of the extent of naturally spawning hatchery fish to the status monitoring program. Therefore, to meet the needs of RPA 182, the status monitoring program must include as population scale indicators, the relative number of hatchery fish spawning in the wild. Specific performance standards for this assessment were presented above. (Fraction of naturally spawning fish that are of hatchery origin, CV < 10 percent.)

Coordination with the Data Management effort (RPA 198)
The implementation of ecosystem and subbasin scale status monitoring projects will necessitate the parallel implementation of a data management system capable of handling the projects' diverse data types. However, the data management system's function is much more than just data storage. The status monitoring program will be implemented by numerous agencies, each contributing a portion of the comprehensive status monitoring program. Thus, data management is key for coordinated implementation of the multiple sub-projects, since many of these sub-projects will be inter-related. For example, habitat surveys may be broken into riparian assessment and water quality assessment components due to the specializations of participating co-manager agencies. Further subdivision of biological sampling is expected, as adult and juvenile fish monitoring will occur via a variety of techniques distributed throughout the year. Thus, a complete picture of habitat and population status is only possible by coordinated data management with strict data quality control enforced to ensure proper alignment of multiple data sets. A data management system will also identify possible efficiencies in program implementation by illustrating duplication of effort and parallel sampling opportunities, especially if a common data management system is applied broadly across multiple RPA Action Item implementation projects (e.g., RPAs 180, 181, 182 and 183). However, the most important role a common data management system will play in FCRPS BiOp RME program implementation is to support evaluation of monitoring data. The overall BiOp performance

standards require the synthesis of data from multiple RPA Action Item implementation projects. As such, the organizing component of the entire BiOp evaluation process should be a data management effort common to all RPAs, in particular, the RPAs specified in the FCRPS BiOp RME program.

B. Appendix B: Action Effectiveness Research (Tributary Habitat) Workgroup Plan

(1) Introduction

Effectiveness monitoring evaluates whether some management action (e.g., riparian enhancement) achieved the desired effect or goal. Success or failure is assessed by statistical comparisons with controls, baseline conditions, or desired future conditions. As such, effectiveness monitoring encompasses the essence of "true" research. That is, the necessary elements of experimental design—randomization, independence, replication, and controls—are often needed to assess effects of management actions on fish and their habitat. As a result, we refer to effectiveness monitoring as "Action Effectiveness Research" (AER), because data will be collected within an experimental design, actions will be evaluated with respect to control sites, variability in the data will be described, and decision making will be based on established rules of scientific inference and statistical confidence.

The overall purpose of the research plan described here is straight-forward: to rigorously assess whether or not tributary habitat actions improve environmental conditions and increase life-stage survival rates, thereby reducing the likelihood of extinction for listed stocks. However, to our knowledge, no previous research program has tried to estimate environmental or fish survival effects of habitat actions on the scale that will be required for BiOp implementation. This will present substantial managerial, logistical, and scientific challenges, as will be seen later in this appendix. Because of the unprecedented scope of the work, success, in the sense of detecting the actions' effects, cannot be guaranteed. However, these challenges do not appear insurmountable at this point.

The establishment of a rigorous AER program is mandated in section 9.4.2.8 of the BiOp:

Action 9: The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5-year plans for research, monitoring, and evaluation to further develop and to determine the effectiveness of the suite of actions in this RPA.

The BiOp also sets a timetable for the development of a monitoring program, and defines the scope for effectiveness monitoring.

> Research, monitoring, and evaluation will provide data for resolving a wide range of uncertainties, including … establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions. Progress on resolving these uncertainties will be a primary consideration in the 1- and 5-year planning process as well as in the 5- and 8-year check-ins. (BiOp, p. 9-31)

Research on tributary mitigation actions is specifically identified in RPA 183:

Action 183: Initiate at least three tier 3 studies[1] (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.

Categories of management actions include:

1. In stream Flow
2. Nutrient Enhancement
3. Barrier Removal
4. Diversion Screen
5. Sediment reduction
6. Riparian Buffer
7. In stream Structure
8. Water Quality Improvement

In addition, section 9.6.5.3.3 of the BiOp states that

> Each major habitat or hatchery management action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points (FCRPS BiOp page 9-170).

For the purposes of establishing a valid AER program, we distilled RPA Action 183 into two primary goals:

1. Evaluate the contribution of tributary actions toward meeting fish population targets for the 5-year and 8-year check-ins *(e.g., answers the question: are projects in aggregate improving fish populations?)*

2. Develop information on the utility of categories of habitat actions to facilitate strategic planning for future habitat mitigation activities *(e.g., answers the question: do barrier removal projects generally work, and if so or if not, under what conditions?)*

These two goals place different demands on the scope of the AER program and the design of monitoring plans for individual actions.

Meeting the first goal will require using the same experimental design standards across groups of research projects. This replication of design will in turn result from careful design of the tested hypothesis. To ensure that the research results from single AER projects can contribute to inferences about population health within a watershed, basin, or even province, the data itself must be collected within a coordinated monitoring plan. This will require similar, rigorous monitoring and experimental designs across projects.

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[1] Note that "Tier 3" refers to action effectiveness. Note as well that the research described here assumes that habitat actions are actually implemented as planned, or, alternatively, that researchers will be aware of actions that were planned but, for whatever reason, were not actually carried out on schedule.

Likewise, the ability to draw inferences about categories of actions will depend on a rigorous program of stratification. It is unlikely that all action types will be successful in all applications. For example, if fish abundance increased in five barrier removal projects, and did not increase in another five, do we recommend continued funding of barrier removal? Answers to questions like this will come from an ambitious program of data collection that enables stratification. Therefore, the AER program should collect data on numerous physical and environmental indicators. Some indicators will be directly related to the progress of the action itself, others may not be related to the action directly, but rather provide information that can allow an evaluation *post hoc*. There is no guarantee that if this additional information is collected it *will* explain the effects of every project, but if not collected it is guaranteed that effects *won't* be explained.

Many subbasins will have multiple action types carried out simultaneously (multiple treatment effects). This will make it more difficult to answer questions about the effects of categories of actions, since many action types will be undertaken in combination with other action types. It will be a continuing task for the RME workgroups to help overcome this difficulty. In addition, we expect that some actions will be sufficiently isolated that their localized effects are largely independent of most other actions.

In an effort to address some of these issues, the Action Agencies and NMFS developed proposed guidelines for sponsors and reviewers of AER projects (Paulsen et al. 2002). The guidelines were directed at research on the effects of specific categories of tributary actions identified in the BiOp. That document, however, did not provide a program for implementing AER activities across different spatial scales. In this appendix, we identify two AER programs that together address the goals and mandates of the BiOp. The first program, referred to as "project-based research", is intended to reveal linkages between a specific management action and the desired outcome. The focus of project-based research is to reveal processes by tracing the effects of specific categories of actions through the ecosystem. The project-based approach is anticipated to be similar to familiar academic research that requires intensive research guided by explicit hypotheses[2] and objectives. The reader is referred to Paulsen et al. (2002) for a more complete description of that program. Programmatic details may also be found in the Project-Based Research RFQ, which will be issued in early 2003. We include cost estimates for this program in this appendix.

The second component of the AER program, which is described principally in this appendix, is designed to address the effects of both existing (ongoing) activities and new or future activities on listed anadromous salmonids. Unlike the project-based research program, which requires the implementation of actions under carefully controlled experiments, this program (referred to as the "Top-Down" approach) accepts the implementation of management actions at any time and does not assume that researchers can control where or how the actions are implemented. The top-down program replaces the loss of experimental control with extensive replication (i.e., the program monitors all management activities within a watershed and many paired control sites).

[2] Hypothesis statements in ecology range from the trivial and uninformative to the truly insightful. At worst, statements such as "I hypothesize that riparian plantings will not decrease the abundance of chinook in a stream," reveal only an ignorance of Type II errors. Project-Based Hypothesis should be explicit and quantitative (e.g., "H_1: Planting willows along five miles of Y stream will increase canopy cover by X percent and thus reduce water temperature Z degrees").

The top-down program has five parts:

1. Identify habitat actions that are or have been implemented;

2. A one-time census of habitat characteristics within the entire region of potential monitoring;

3. Present hypotheses for the effect of actions;

4. Collect data within a stratified scheme that includes:
   - Monitoring of on the same subset of indicators at all treatment (action) and control sites,
   - Monitoring of a consistent set of sub-population and biological productivity indicators at a fewer number of key, informative locations;

5. Estimate the magnitude of effects on fish associated with management actions (pathways 1 and 2 in Figure B.1)

The BiOp requires that all AER programs demonstrate cause-and-effect relationships. Therefore, the top-down approach must be based on well-designed research experiments with controls and replication. This places particularly demanding expectations on the program, which cannot be satisfied by status and trend monitoring. Because the top-down approach is novel and has never before been implemented, the program itself becomes an experiment of sorts. Consequently, the Action Agencies and NMFS will test the top-down approach within three pilot subbasins, the Wenatchee, John Day, and the Upper Salmon. Below, we describe this program in greater detail.

(2) Performance Standards

The AER program will estimate environmental and biological responses to habitat actions. Just as one would define the performance of any measurement tool in terms of resolution and precision, the performance of the AER program must be specified. The standard for AER performance is the ability to test the posed hypothesis. The measure of this is statistical power. Normally, one would establish the precision of such a tool based on some *a priori* knowledge of the likely size of changes in the monitored variable(s). Currently, there are no well established estimates of the effect of any action category on any indicator. It will be a continuing task for the AA and NMFS to develop more specific performance standards for effectiveness research. The pilot project in the three subbasins, and a parallel pilot project-based research program, will help achieve this task.

As pointed out by the ISRP review of Paulsen et al. (2002), whatever standards are adopted by the regional effectiveness monitoring program, it is very unlikely that single habitat projects – even with carefully paired controls – will be powerful enough to satisfy them. Therefore, monitoring will need to be coordinated so data from a suite of projects of the same category can be pooled to increase overall statistical power. This requires rigorous replication of experimental design across projects. Monitoring protocols must be compatible, and resulting data must be freely shared. For this reason, the Action Agencies and NMFS have decided to take a top-down approach to the problem. The basic idea is to monitor all tributary actions that may affect environmental conditions, survival, fish condition, and distribution in the three pilot subbasins, and to monitor control sites as well. The three pilots will expand to six in 2004, with more subbasins added in 2005. Later sections of this appendix contain details on the monitoring effort and outline the proposed analytical approach.

(3) Tributary RME Needs Assessment

BiOp RPA 183 requires the Action Agencies to assess the effects of tributary habitat actions on the survival of listed stocks. In addition, because multiple actions may affect survival simultaneously, the Action Agencies and NMFS will also try to detect the effects of actions on localized fish distribution and on the environment.

Unfortunately, while it should be possible to take advantage of ongoing monitoring to help inform tributary effectiveness research, we have found no research – ongoing or proposed – funded through the NPPC program that directly addresses the issue of tributary action effectiveness as defined above. In fact, a recent review (Bayley, 2002) of almost 2,500 references found only a handful of peer-reviewed or gray-literature studies of tributary action effectiveness. Therefore, this program will be starting from scratch.

Therefore, the Action Agencies and NMFS propose a two-pronged approach to the problem. The first, described in Paulsen et al. (2002), is an RFQ for project-based monitoring/research on a subset of the eight categories of actions outlined under RPA 183. The second, described in more detail in the Action Plan below, calls for monitoring all sites (in three subbasins) of tributary actions intended to increase survival rates for ESA-listed anadromous fish. The Action Plan also calls for monitoring of paired control sites (where no actions are taken) and outlines how the resulting data would be analyzed.

(4) Action Plan

This plan shows how existing monitoring activities (e.g., redd counts, parr density surveys, juvenile PIT tagging) may be integrated with additional monitoring and experimental designs (as outlined in Paulsen et al. 2002) to assess the effectiveness of ongoing and future habitat management actions on listed anadromous salmonids. The Paulsen et al. (2002) guidelines address how individual action effectiveness research projects should be implemented to assess cause-and-effect relationships of specific management actions. It was concerned with designing valid studies, replete with controls, replicates, and, if possible, randomization. An implicit assumption in that document was that the effectiveness research program would be implemented by knitting together a substantial number of effectiveness research projects. Each research project, in turn, was assumed to monitor and analyze the effects of several habitat actions. In contrast, this appendix focuses on how the suite of existing monitoring studies and future action effectiveness studies (which follow the guidelines in Paulsen et al. 2002) can be used to address the requirements of BiOp RPA 183. Also, the current report assumes that tributary habitat actions will occur independent of the effectiveness research, so research will be confined to assessing the effects of past, current, and future habitat actions. As such, this appendix describes a “top-down” approach to action effectiveness research, unlike Paulsen et al. (2002), which describes a “bottom-up” approach. Both approaches are necessary and need to be integrated in order to adequately assess management actions across the landscape. For the purposes of this report, we describe the top-down approach using the three pilot subbasins.

There will also be a parallel track of "project-based" monitoring and research. This project-based program will choose an action category (or categories) and geographic locations within or across ESUs. It will perform the necessary experimental study to determine the effectiveness of those actions, and the mechanistic basis for the future effectiveness of similar actions. Eight action categories, each with up to two research projects, may be funded. RFQs will be issued in early 2003. See these for more details.

(5) Management Actions and Objectives

The BiOp and Paulsen et al. (2002) identified several categories of management actions to be monitored for effectiveness, as noted previously. The work by Paulsen et al. (2002) outlines methods for assessing the effectiveness of these actions, but it does not describe how the assessments fit into the overall monitoring program at large spatial scales.

The BiOp gives some direction on monitoring the effectiveness of these management actions. For example, tributary effectiveness research, called for by BiOp RPA 183 (and others), has several overlapping objectives. First, the Actions Agencies must demonstrate that habitat actions have increased tributary life-stage survival rates of affected populations. Second, for actions that remove passage barriers or change patterns of local juvenile abundance, they must demonstrate that this newly opened or improved habitat is actually being used by listed stocks. Third, they must show that increases in life-stage survival rates contribute to increases in adult population growth rates (λ, recruits per spawner, etc.). Fourth, they must show that physical/environmental habitat conditions improved. Finally, they must be able to show cause-and-effect relationships between survival rates or use of new habitat and the actions taken in the tributaries.

With these objectives in mind, the purposes of this appendix are to:

1. Design a monitoring program to detect life-stage survival changes (e.g., egg-fry, fry-parr, parr-smolt, spawner-adult recruit), local changes in distribution, and changes in physical/environmental conditions for the three pilot subbasins.

2. Design an effectiveness research program to detect cause-and-effect relationships between management actions and effects on tributary environment and fish survival rates.

3. Design a program to assess the effects of management actions at different spatial scales (i.e., ESU, population, subpopulation, and reach scales).

To meet these objectives, we outline the design of a large-scale tributary effectiveness experiment, including variables to be monitored, protocols for measurements, the spatial density and temporal frequency of measurements, and the number of populations that would be part of the experiment. The actions to be monitored will be ongoing and proposed tributary habitat projects, both those funded by BPA/NPPC and other agencies. We also compare the required monitoring to current monitoring, briefly discuss data management issues we expect will arise, and provide some very rough estimates of costs for filling in the gaps. In addition, we describe briefly the data and analytical products that we expect will result from the exercise. Finally, we lay out the steps that should be taken to fill gaps in existing information, and describe next steps in acquiring new information. As will be seen below, if the monitoring and research described here is put into place, it should be possible to evaluate changes in survival, local abundance, and environmental conditions caused by tributary habitat actions using a single database and analytical framework.

Monitoring at Different Spatial Scales

Action effectiveness research can be conducted at different spatial scales, depending on the objectives of the study. For example, one can assess the effect of a management action on a specific ESU (which may encompass several populations), a specific population (may include several sub-populations), at the sub-population level (may encompass a watershed within a basin), or at the reach scale. Clearly, the objectives and hence the indicators measured dictate the spatial scale at which action effectiveness research is conducted. For example, if the objective is to assess the effects of nutrient enhancement on egg-smolt survival of a specific sub-population of spring chinook, then the spatial scale covered by the study must include the entire area inhabited by the eggs, fry, parr, and smolts. If, on the other hand, the objective is to assess the effects of a sediment reduction project on egg-fry survival of a local group of spring chinook (i.e., chinook within a specific reach of stream), then the study area would only encompass the reach of stream used by spawners of that local group.

In theory there might be no limit to the scale at which effectiveness monitoring can be applied, but in practice there is a limit. This is because as the spatial scale increases, the tendency for multiple treatments (several management actions) affecting the same population increases (Table B.1). That is, at the spatial scale representing an ESU or population, there may be many management actions within that area. Multiple treatment effects make it very difficult to assess the effects of specific actions on an ESU (see Hillman and Giorgi 2002). Even though it may be impossible to assess specific treatment effects at larger spatial scales, it does not preclude one from conducting effectiveness research at this scale. Indeed, one can assess the combined effects of the management actions on the ESU or population. However, additional effectiveness research is needed at finer scales to assess the effects of individual actions on the ESU or population.

If the biological indicator of interest is some life-stage-specific survival, as noted frequently in the BiOp, we believe that for most life-stage-specific survivals (fry-parr, parr-smolt, egg-smolt, spawner-adult recruit), the spatial scale should be equal to the area occupied by a specific sub-population. Here, we define sub-population as the smallest geographic unit where juvenile life-stage survival can plausibly be assumed to be independent of other sub-populations. One cannot measure independent fry-to-parr, parr-to-smolt, and recruit-per-spawner survival rates at smaller scales because of mixing and migration. For egg-fry survival, the spatial scale could be smaller because eggs and alevins are more confined in space than are fry and parr, which tend to move both upstream and downstream from spawning locations. Although the sub-populations are similar to distinct population segments the DPS designation has other implications for management, analysis of extinction probabilities, etc.

Because of the conflict between spatial scale and multiple treatment effects, and thus our ability to assess specific management actions, there may be times when we cannot effectively analyze the effects of individual management actions on life-stage-specific survival of specific sub-populations. This can, for example, occur if multiple actions may increase parr-to-smolt survival rates for a particular sub-population. These might include riparian plantings, irrigation screening, and flow increases. In this case, it will be necessary to measure other indicator(s) to assess the effectiveness of specific management actions. Other biological indicators identified in the BiOp include distribution, abundance, growth, and condition. In addition, the BiOp calls for the monitoring of physical/environmental attributes. These too can be used to assess the effects of management actions. Therefore, to establish the linkages between management actions and biological indicators as called for in the BiOp one will need to measure physical/environmental indicators. These studies often can be conducted at scales small enough to avoid treatment effects from multiple management actions. They can also help infer which action or actions had the greatest affect on life-stage-specific survival at the sub-population scale.

Relationship with Status Monitoring

Because effectiveness research will occur at a range of spatial scales, there may be some confusion between the roles of status monitoring and effectiveness research. We often think of status monitoring as monitoring that occurs at coarser spatial scales and effectiveness research at finer scales. In reality, both will occur across different spatial scales, and the integration of both is needed to develop a valid monitoring program.

As reported in Hillman and Giorgi (2002), status monitoring is used to characterize existing conditions. The intent is to capture temporal trends and variability in the parameters of interest. Effectiveness research, on the other hand, evaluates whether the management actions achieved the desired effect or goal. Success or failure is assessed by statistical comparisons with controls, baseline conditions, or desired future conditions.

Although there is a definite distinction between the two types of analysis, they often rely on the same monitoring data. For example, suppose one has in hand monitoring data on egg-smolt survival over time for several sites. Analysis of the data under a status monitoring program is concerned with describing parr-smolt survival over time (looking for trends). In contrast, effectiveness research is interested in assessing whether parr-smolt survival changed as a result of some management action. What makes effectiveness research different from status monitoring/analysis is that effectiveness research compares parr-smolt survivals in treatment and control areas and makes inferences regarding cause-and-effect based on those comparisons. Status monitoring does not use controls and therefore is not designed to identify cause-and-effect relationships. In short, both types often measure the same thing, but they use the data very differently, since they have different objectives and purposes.

It then follows that the data collected for action effectiveness research can be used for status monitoring,[3] but the reverse may not be true. For example, as part of a status monitoring program, one may measure egg-smolt survival over a period of 5 years within a watershed that has been treated with a set of riparian vegetation plantings. These data cannot be used to assess the effects of the treatment, because there were no survival estimates collected from reference or control areas, so any change in survival could be ascribed to causes other than the riparian plantings. Thus, in this case, status monitoring cannot be considered effectiveness research.

Only under specific circumstances can status monitoring data be used in effectiveness research. For example, an existing status monitoring program may have measured egg-smolt survival

3 Exceptions are possible depending on the specific objectives of status monitoring. For example, the spatial extent of effectiveness research may not be sufficient for a given status monitoring program. This does not mean that the data collected for effectiveness research cannot be used. Instead, additional data may be needed to satisfy the objectives of status monitoring.

within a watershed for the last 5 years. After the fifth year, the watershed is treated with some management action. Monitoring continues to measure survival following the treatment event. In this case, status monitoring becomes action effectiveness research when the survival data before treatment (control) are compared to survival data after treatment.

Because the BiOp calls for both types of monitoring, and because both types often measure the same variables, the following plan has a mix of both status monitoring and effectiveness research. This integrated approach avoids unnecessary, repeated sampling of the same parameters and thus reduce total monitoring effort and cost.

(6) Experimental Design

(a) Classification of watersheds

Prior to conducting action effectiveness research, it will be necessary to classify the ecologic and geologic characteristics of the landscape supporting distinct sub-populations (as defined above). We recommend the hierarchical classification system proposed in Hillman and Giorgi (2002) and Paulsen et al. (2002). That system includes descriptions of processes at the regional, drainage basin, valley segment, and channel segment scales (Table B.2). Investigators should use the classification protocols identified in Table B.2. Control sites for project-based monitoring will be selected based on their similarity to treatment sites, again using the variables described in Table B.2.

(b) Detecting changes in survival due to habitat actions

The following guidelines for detecting survival changes are based on a couple of straight-forward considerations. First, the main driver for effectiveness monitoring is changes in survival rates. Second, as noted above, below the sub-population scale it makes little sense to try to measure survival rates.[4] To make a difference in adult abundance over time (or λ, recruits per spawner, etc.), changes in life-stage survival rates must eventually translate into changes in survival or growth rates for adults. Any tributary action that only affects a portion of the sub-population will have a proportionately small effect on population growth rates. Although juveniles are generally thought to migrate downstream on net (e.g., Bjornn 1978), they are highly mobile. Therefore, almost any action, to be effective at increasing adult numbers, must affect most or all of the target sub-population.

As we described earlier, there are a few exceptions to this general rule. One would be measurements of localized effects of actions on fish distribution and on the environment, which we cover in later sections. Another might be measuring the survival effects of actions that affect only a portion of the population's spawning area. Here, egg-fry survival can be monitored at the reach scale. Finally, multiple treatment effects at the sub-population scale may force us to conduct effectiveness research at smaller spatial scales using biological or environmental indicators other than survival rates.

Table B.3 contains a preliminary identification of the 10 to 15 sub-populations, grouped by HUC, and a first-round attempt at identifying ongoing biological and habitat monitoring

[4] As noted earlier, we use "sub-population" to denote the smallest geographic or population unit where life-stage survival rates can be estimated independently. The Technical Recovery Team is charged with designating Distinct Population Segments.

activities for each of the three pilot areas for top-down studies. These will surely be revised as more information is collected. For example, the BiOp treats the Wenatchee as a single population, while Table B.3 breaks it into three populations. Identification of ongoing monitoring is based on personal knowledge, and needs to be extensively checked against reality.

To estimate life-stage-specific survival rates, one often needs to estimate life-stage-specific abundance (mark-recapture studies usually avoid this requirement). We summarize these biological variables in Table B.4. Adult counts for most populations are conducted at weirs or by counting redds, and (at least for chinook) are believed to cover most of the spawning reaches for most stocks. In combination with annual, sub-population-specific return-at-age estimates, these can be used to estimate recruits per spawner. The spatial coverage could be expanded, if needed, so that one could regard them as a near-census, setting detectability, miss-counts, etc. aside. For Upper Columbia stocks the entire known spawning areas are covered at 2-week intervals for the duration of the spawning season. In the past, Idaho relied, for the most part, on "peak," once-off counts in index areas, but coverage has been expanded to cover all known spawning areas with repeated counts. We understand that Oregon is currently doing repeat counts of all known spawning areas, but need to confirm this.

For juveniles, one would tag parr in rearing areas each year, but probably not for the entire length of the area. Tagging more than 1,000 to 3,000 parr per population does little to increase the precision of parr-to-smolt survival estimates (at least for Snake populations; numbers will be larger for the Wenatchee and John Day). We need to investigate this further to discover the extent of current efforts, and what additional precision would be gained by increasing the number of parr tagged. The results from this effort would be estimates of parr survival to the first dam with PIT tag detectors they encounter (LGR, MCN, or JDA). Details of survival rate estimates can be found in Paulsen and Fisher (2001) and references therein.

Table B.4 also mentions two potential measures that are more problematic: parr density and parr abundance. While parr density surveys were conducted in Idaho Supplementation Study streams for 10 to 15 years, they have recently been discontinued by IDFG since the resulting estimates were imprecise. The utility of these techniques depends on the research objectives and the questions the methods intend to answer. For example, if one is looking for reliable estimates of juvenile abundance that can be compared across populations, this will at best require intensive, intrusive, sophisticated sampling efforts, and at worst may be impossible. If, on the other hand, the objective is to see if the spatial distributions of juveniles change over time in response to habitat actions – with fish moving above former passage barriers or congregating in areas with improved in-stream habitat – this can probably be achieved with comparatively modest sampling effort.

As noted in Table B.3, systematic parr and smolt emigrant abundance estimates are currently available for some populations. Typically, fish are screw-trapped in the fall and spring and estimates of detection probabilities are made simultaneously. We have not investigated the precision of the estimates, nor how complete they may be, in light of common problems during high flow events and other logistical problems. In addition, juveniles may leave rearing areas near their natal spawning areas as fry (Bjornn, 1978), complicating efforts to obtain unbiased estimates of juvenile abundance. It appears from Bayley's (2002) review that researchers rarely try to account for bias in abundance estimates even when they acknowledge that bias is a possibility. As with the fry and parr problems noted above, the importance of these potential problems depends upon the research objectives.

(c) Detecting changes in local fish distribution

Different action types probably will have differing effects on local fish distributions, as shown below in Table B.5. We divide the monitoring into two different categories, since the intensity (and hence the costs) of the categories will be quite different, with changes in presence/absence due to actions being substantially less expensive than changes in juvenile densities. As noted above, the intensity of the effort depends on the objectives. In particular, monitoring to enable analysis of changes in parr density between sites over time will be very costly, and may be impossible as a practical matter.

We believe that the best approach to fish distribution monitoring for effectiveness research will be to select reaches above, within, and below habitat actions (treatments), and comparable control sites, then monitor the same locations each year, per the previous section. How extensive this effort will be depends, in turn, on how many action sites or reaches we can locate in the habitat action inventory described later. We think this will suffice to detect changes in juvenile (parr) distribution as a result of barrier removals and other actions that change fish distributions. Validation of the design will require consultation with both statisticians and field workers from other programs, such as EMAP, and the continuing evaluations of the AER program products.

(d) Detecting changes in physical/environmental conditions

Table B.6 contains physical/environmental indicator variables for effectiveness monitoring. Flow and water temperature would be sampled continuously at fixed gauging stations located in the lower reaches of each population. In some cases, where actions are expected to have substantial effects on these variables, one would sample upstream and downstream from treatment and control reaches as well. Similar spatial density would probably be needed for other water quality measures.

We propose that for the remaining variables in Table B.6, one would do treatment and control reach sampling similar to the juvenile sampling (previous section). The detailed habitat surveys would be conducted at the same times and locations as the surveys for juveniles.

(e) Data and analytical products

Data for the sub-populations at the end of 2007 will consist of the following.

One-Time:

- Census of classification variables (Table B.2), probably updated no more than once at the start of the program.

Sub-population scale/Integrating indicator monitoring:

- Water quantity and quality measured in lower reaches of each population and perhaps upstream and downstream from some project sites;

- Annual redd or weir counts for spawning adults (multiple counts of entire spawning reach where feasible, peak index counts otherwise), with return-at-age information for each year;

- Annual estimates of parr and smolt emigration;
- Parr PIT tagging of 1,000 to 3,000 parr tagged each year.

Reach-scale indicator monitoring:

- Annual parr density surveys for treatment and control reaches;
- Annual physical/environmental indicators from Table B.5 for treatment and control reaches;
- Annual estimates of hatchery origin fish on spawning grounds, and outplants of hatchery juveniles.

In addition to the biological and environmental data, a critical part of the effort will be compiling a detailed inventory of past, current, and planned habitat projects. The inventory is required to select treatment and control monitoring sites, to assess how extensive the required juvenile distribution and detailed habitat monitoring effort will be, and will also be useful for other programs (e.g., subbasin planning). The inventory will be a substantial effort in its own right; a pilot effort on the Clearwater has consumed 2 to 3 person-months.

We want to be able to answer a variety of questions at different spatial and temporal scales:

1. Do subbasins or sub-populations in aggregate help move an entire ESU toward recovery goals?
2. Did habitat projects in aggregate within a sub-population increase recruits per spawner, life-stage survival rates, etc.?
3. Is an individual habitat project in a given reach effective in changing fish distributions or improving environmental conditions?
4. Are classes of projects effective, and why or why not?

Figure B.2 contains a graphical representation of questions 1 to 3. In Figure B.2A, one can see that each ESU is comprised of a number of subbasins. Figure 2B shows how subbasins, in turn, are inhabited by one or more sub-populations (by definition, sub-populations are quasi-independent, so that their survival rates are independent of one another, and local actions taken for sub-population i do not affect sub-population j, $i \neq j$. Each sub-population, in turn is affected by one or more habitat actions (Figure B.2C)).

The scale of this experimental design, with dozens of sub-populations affected by hundreds of actions, may be somewhat daunting. In the rare cases where published analyses of action effects exist (e.g., Bayley 2002 lit review), the usual approach is to have a small number of treatment and control sites – say 5 to 10 – where actions occur, affecting an even smaller number – say 2 to 4 – of sub-populations. What we attempt to show below is that the top-down approach may be viewed as a similar sort of experiment, but at a much larger geographic scale. In doing so, we move from small (reach) to large (ESU) scale.

We note at the outset that, in the strict sense, the top-down design cannot guarantee a true cause-and-effect analysis. Cause and effect inferences are only possible with discrete treatments and controls that differ only in the treatment being tested. In ecological experimentation the natural differences that exist between sites makes it impossible to guarantee this discreteness of treatment. However, the comprehensiveness and large scale of our program creates the greatest opportunity possible to identify cause and effect relationships in this system.

It is also important to recognize a difficulty in making inferences between effects of actions and sub-population responses. The problem is that treatment sites – where habitat actions occur – are not chosen randomly. In a “true” experiment, one would randomly choose treatment and control sites, which could then be treated as “representative,” and then generalize results to the entire experimental area. Instead, managers, at least in theory, choose locations where they believe the actions will be most effective. Therefore, if an action is shown to be effective, one cannot generalize its effects to all locations in the experimental area. However, it is reasonable to generalize effects to similar sites or locations.

Figure B.3 shows an example sub-population. It has three actions – riparian planting in a juvenile rearing reach, sediment reduction in a spawning reach, and a barrier removal on a small tributary. The entire length accessible to spring chinook (including small tributaries not shown in the diagram) will be surveyed for the eight variables listed under question (1), above, in 2003. A gauging station for measuring flow, water temperature, and water chemistry is located at the bottom of the system.

Counts of adults are conducted in summer/fall at a weir at the bottom (lower right) of the system. Red counts and carcass surveys (for age, sex, and hatchery origin) are also done in the spawning reach near the top (upper left) each year. Juvenile emigrants (parr in summer, smolts in spring) are caught at a screw trap above the weir, and, in conjunction with PIT tagging of all captured fish and re-release of some fish above the trap, estimates of trap efficiency and hence emigrant abundance can be made each year.

The treatment and control reaches (three of each) will be intensively monitored each year for the environmental variables described above, and for juvenile (parr) density. Similar monitoring is also occurring for sub-population 1B (right-hand side of diagram), and assumed for convenience that sub-population 1B has no habitat actions occurring, with six sites (reaches) intensively monitored. We will also assume that all monitoring occurred for both sub-populations for 5 years before any actions were taken for 1A. Finally, we assume tagged juveniles are detected at mainstem dams.

So, for this example, one would have 5 years of pre-treatment and 5 years of post-treatment data for 1A, and 10 years of “control” data for the same time period for 1B. One would of course have a long list of data collected, but for this example we focus on a couple of reach-scale variables – sediment and parr density – and on two sub-population scale variables – parr-to-smolt survival and smolts per spawner.

In this small example, with two sub-populations and three habitat actions, one can test a number of hypotheses, going from smaller (reach) scales to larger (sub-population) scales. These might include:

1. Sediment in spawning gravels has decreased at the (single) treatment site compared to both pre-treatment conditions, the control site for sub-population 1A, and control sites for sub-population 1B.
2. Parr density has increased at the riparian treatment site compared to both pre-treatment conditions, the control site for sub-population 1A, and control sites for sub-population 1B.
3. Parr-to-smolt survival has increased for sub-population 1A compared to pre-treatment conditions and compared to sub-population 1B.
4. Smolts-per-spawner has increased for sub-population 1A compared to pre-treatment conditions and compared to sub-population 1B.

Statistical methods would, of course, be a basic Before-After-Control-Impact (BACI) design for testing all four hypotheses, since by assumption one would have 5 years of pre-treatment data for both sub-populations and the 12 reaches (six per sub-population). If no pre-treatment data had been collected (which implies a different experimental design), one would need to rely on simpler but less powerful paired treatment-control designs. The latter approach, of course, runs a risk: if sub-population 1A *always* had lower sediment levels, higher parr density, etc. than 1B, one might confuse this with improvements due to the habitat action(s).

Other potential problems at this scale are amenable to reasonably well-established solutions. For example, there will be a plethora of potential independent variables that could be used in regression or ANOVA models. All of the variables noted above – flow, temperature, stream characteristics, etc. – might be important in explaining differences between treatment and control sites. One approach – assuming one is using models with maximum likelihood solutions – is to use Akaike Information Criterion (AICc) weights, corrected for degrees of freedom, to select the most plausible model(s).

Solutions to some statistical problems are less clear-cut, of course. For example, if an action increases egg-to-fry survival rates, then, absent density dependent effects, one would expect that abundance would increase at all subsequent life stages (i.e., parr, smolt, and adult). Since the monitoring effort may well generate abundance estimates at each life stage, there will likely be a temptation to try to estimate separate models for effects of habitat actions on, for example, parr per spawner, smolts per spawner, and adult recruits per spawner, and use the "best" model to evaluate the results. At some level, however, this is clearly incorrect, since the three models would not be truly independent of one another. Hierarchical Bayesian or multi-variate methods may be useful here to account for the interdependence among models and dependent variables.

In any event, the preceding sort of analysis has been done before (e.g., Solazzi et al 2000) on the scale of a watershed or subbasin with a few actions and a few affected sub-populations of juveniles. So what happens if we try to scale up the analysis from 1 or 2 sub-populations and a few actions to 5 to 10 sub-populations and many actions? The basic statistical methods – BACI, etc. – do not change. What does change is that the categorical or classification variables – ecoregion, channel characteristics, etc. – may come into play to help explain differences among survival rates for sub-populations or reach-level effects for actions. For example, it may well be the case that the effectiveness of riparian planting varies with both the pretreatment conditions and the quality of surrounding habitat. That is, if prior to treatment riparian habitat quality is very poor, treatment may be more effective than if existing habitat is in fair condition. Similarly, if surrounding habitat is in poor condition, treatment may be more effective at attracting juveniles than if surrounding habitat is already in good condition. An analysis at this scale is, to our knowledge, unprecedented, and surprises are to be expected. In addition, as the number of actions and action types increases with the number of sub-populations analyzed, it should be possible to draw inferences about the local effects of different action types.

Finally, what might one do with an analysis that examines the effects of actions on the ESU scale, with 50+ sub-populations (this requires extending the effort beyond the pilot subbasins, as will occur in 2004 and later)? Two broad possibilities come to mind. First, depending on the luck of the draw for how actions and action types are distributed across sub-populations, it may be possible to determine how effective different action types are at increasing survival rates. If, on the one hand, all sub-populations have roughly the same mix of action types, then it will be very difficult to determine which actions are contributing the most to changes in survival rates. On the other hand, if action types are concentrated in particular sub-populations – with some having mostly irrigation screening, others mostly flow augmentation, etc. – then we should be able to tease out the effects of each class, since we will have many observations on life-stage survival in hand by 2008. The second possibility is that we may be able to track the effects of habitat actions on the ESUs as a whole. Again, this will depend on the luck of the draw, since in this case we would want some sub-populations to be "intensively" treated, with many habitat actions, while others are subject to few or none. If that is indeed the case, then there should be substantial contrast in the changes in life-stage survival rates, recruits per spawner, and trends in adult abundance among the stocks. These differences, in turn, should be detectable using BACI designs or related statistical models.

As noted, no fish habitat effectiveness research, monitoring, and analysis has ever been attempted on this scale. Surprises – pleasant and otherwise – are therefore to be expected. We have few, if any, well-established estimates of effect size. In many cases experienced habitat analysts believe that effect sizes are likely to be small and therefore difficult to detect. Doing true controlled experiments on this scale is impossible due to uncontrollable natural anthropomorphic disturbances and non-random assignment of treatment sites. Finally, standardized monitoring on the scale proposed, with attendant quality assurance/quality control, data management and access, etc. will be a substantial management challenge in its own right. While all of these are reasons to be cautious about predicting the ultimate outcome of the experiment, none appear at this point to be an insurmountable obstacles.

(7) Data management and Costs

(a) Top-down costs

Data collected following QA/QC protocols by field crews and their managers would then go to repositories that, in turn, would make it available to anyone interested in doing summaries and analyses. Again, this needs much additional thought and discussion since this sort of ready access to detailed current monitoring data has few regional precedents, PTAGIS (for PIT tag detections) being a notable exception. Close adherence to common data collection, QA/QC, and reporting protocols will be essential for comparisons across sites and sub-populations.

Obviously, to arrive at costs for annual sampling of treatment and control reaches, one needs estimates of both per-site or per-mile costs and estimates of the number of sites that need to be sampled. Very rough costs per mile appear to be about $2K to $4K, including costs for measuring the habitat variables in Table B.6 and snorkel surveys to estimate changes in parr density/distribution. At least in the Snake, extensive juvenile tagging and density surveys are already ongoing. In Idaho, for example, about 10 percent of the habitat suitable for parr has been snorkeled each year. As noted, however, many of these surveys have been discontinued.

Lengths of survey sites (treatment and control) will range from a minimum of 150 m to a maximum of 20 times the mean bankfull width. If one were to monitor a total of 1,000[5] sites, and the average length is about 500M (approximately 1/3 mile), the resulting annual cost would be about:

1,000 sites * 1/3 mile per site * $4K per mile = $1.5M per year.

A guess at additional biological sampling not included in the above would be $500K to $1M per year, roughly $30K to 50K for each of the 15 sub-populations, with many needing little new effort. This would cover PIT tagging efforts, juvenile (parr and smolt traps), and increased redd or weir counting efforts, as needed.

Other costs would include additional stream gauging, data management, and data analysis. We do not have a good sense for how extensive the stream gauging network is, but suspect that the majority of sub-populations are already gauged, and therefore assume that the additional cost is minimal. Data management, including QA/QC, data access via the Web, etc. might add $50K to $100K. This number is based on a rough-and-ready extrapolation from the annual data management costs for PTAGIS (199008000 , $795K for their Task 1), and an assumption that the volume of data to be managed will be far lower than 1 million or so PIT tags PTAGIS tracks each year. Data analysis costs are difficult to estimate, but seem unlikely to run more than $200K to $500K per year, based solely on professional judgment.

So, the total for the three pilot basins might be annual costs of about $2.5M to $3M in round numbers. This does not include the cost of the habitat inventories, which might run an additional $100K. Whoever conducts the inventories should probably be charged with collection and compilation of existing biological data and metadata as well. While the cost estimates will surely change as we acquire better information on per-mile survey costs, additional tagging that may be needed, etc., these appear to be in the right ballpark, at least.

Project-based research costs

Costs for the project-based research program are calculated for monitoring only. If habitat actions must be undertaken to have something to monitor, those costs are not included. Each project-based program will be a unique research project designed to assess the effectiveness of a given type of action as defined in the BiOp. Therefore, the details of implementation and costs will be unique. Thus, the following cost estimate is a rough guide and it is possible that significant economy will be achieved in the actual implementation. Until that time, however, we need to be aware of the potential cost of this program as specified in the BiOp.

[5] Based on very rough estimates of 150 sites in the John Day, 100 in the Wenatchee, and 300 in the upper salmon, with a roughly equal number of control sites. The 1/3-mile estimate will be high in many cases, where stream width may be 10 m or less.

Analysis of the intrinsic variability of habitat data (Kaufmann et al. 1999) indicates that satisfactory statistical power can be obtained with 30 replicates per action category within the boundaries of a single study. If each replicate has a single paired control reach, that defines 60 sites per study as an initial estimate. If actions impact life stages in different seasons then one would need to repeat sampling within a single year to assess the impacts of actions in both spring and fall. If half of the studies fall into this category 90 site visits would be needed.

As noted in the previous section, rough costs per mile appear to be about $2K to $4K, including habitat variables and snorkel surveys. Hughes et al. (2002) suggest that as much as 85 wetted widths may be required to estimate 95 percent of present species richness. Given a value of 25m for wadable streams in this program, this suggests a minimum sample of 2.13 km or 1.36 miles. Since abundance sampling is a statistical estimate, it is likely that the minimum dimension required for estimating abundance can be smaller than for diversity. Thus, we round down and use 1-mile sample reaches. If each study required approximately 90 samples, $2K to $4K gives a range of costs of $180K to $360K for field expenses for each study.

In addition to field expenses, data and project management as well as logistical support for field crews must be accounted for. If the studies are assumed to be independent, the costs for managing these projects will need to be attached to all 16 projects. This additional cost is estimated at $100K for project and personnel management.

This puts the estimated range at roughly $500K for each project. It is very likely that economies can be achieved if multiple projects are managed by the same entities or if activities can be combined with those of other programs, but for now we have no way to guarantee this. It is unknown at this time what number of project-specific studies would be needed until the success of the top-down approach is determined through the pilot studies. If the top-down approach is expanded as proposed, these project specific studies would be rolled up into that broader program.

(8) Next Steps

This is, obviously, an ambitious and unprecedented undertaking, even for the pilot studies. While it appears to be both feasible and relatively inexpensive, no effectiveness studies have ever been attempted on this scale. In fact, Bayley (2002), in a review of over 2,000 salmonid habitat studies, found almost none that systematically evaluated the survival effects of habitat actions. On the other hand, something of roughly the scope and extent of the program described here appears to be needed to fulfill BiOp obligations for tributary effectiveness research. One fringe benefit is that the data collected should fulfill parallel obligations for status monitoring for the stocks in question. Perhaps more importantly, the program offers the possibility of discriminating between action categories that work well and those that do not, leading to better use of habitat expenditures in the future.

So, what needs to be done next? A first step would be to validate/correct the biological monitoring entries in Table B.3, see how far back they extend in time, and, where possible, get estimates of their precision. It is likely that we will need to add some additional columns to the table for other life stages and survival rates. For example, in many Snake tributaries where smolts are tagged, one can make separate estimates of parr-to-LGR and smolt-to-LGR survival rates. The habitat project inventories would clearly be useful as well. RFQs will go out soon. A draft schedule is shown in Table B.7.

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Table B.1. Relationship between biological indicators, spatial scales, and our ability to assess effects of specific management actions. Examples of each scale are shown in parentheses.

Biological Indicators	Example of spatial scales	Ability to assess effects of specific management actions
ESU (Snake Spring/summer chinook, Upper Col. Spring chinook) ↓ Population (Middle Fork Salmon spring chinook, Wenatchee spring chinook) ↓ Sub-Population (Marsh Ck. Spring chinook, Nason Ck. Spring chinook) ↓ Local Group	Basins (Snake, Upper Col.) ↓ Basin (Middle Fk. Salmon, Wenatchee) ↓ Watershed (Marsh Ck., Nason Ck.) ↓ Reach (100 m. of Marsh Ck., 1 km of Nason Ck.)	Low ↓ High

Table B.2. List of classification (stratification) variables that will be measured as part of effectiveness research. The variables are nested according to spatial scale and their general characteristics. Recommended sampling protocols are also included (Table is from Hillman and Giorgi 2002).

Spatial scale	General characteristics	Classification variable	Recommended protocol	Sampling frequency (years)
Regional setting	Ecoregion	Bailey classification	Bain and Stevenson (1999)	20
		Omernik classification	Bain and Stevenson (1999)	20
	Physiography	Province	Bain and Stevenson (1999)	20
	Geology	Geologic districts	Overton et al. (1997)	20
Drainage basin	Geomorphic features	Basin area	Bain and Stevenson (1999)	20
		Basin relief	Bain and Stevenson (1999)	20
		Drainage density	Bain and Stevenson (1999)	20
Valley segment	Valley characteristics	Valley bottom type	Cupp (1989); Naiman et al. (1992)	20
		Valley bottom width	Naiman et al. (1992)	20
		Valley bottom gradient	Naiman et al. (1992)	20
		Valley containment	Bisson and Montgomery (1996)	20
Channel segment	Channel characteristics	Elevation	Overton et al. (1997)	20
		Channel type (Rosgen)	Rosgen (1996)	20
		Bed-form type	Bisson and Montgomery (1996)	20
		Channel gradient	Overton et al. (1997)	20
	Riparian vegetation	Riparian cover group	Overton et al. (1997)	5
		Riparian community type	Overton et al. (1997)	5

Table B.3. Preliminary identification of sub-populations and ongoing monitoring for John Day, Wenatchee, and Upper Salmon. All 14 areas have sub-populations of both chinook and steelhead, although chinook in the John Day are not listed under the ESA. Data collection ("X") is thought to apply to both chinook and steelhead.

Stream Name (From Streamnet)	HUC #	HUC Name	Redd/ weir counts	Parr Density	Juvenile PIT Tagging	Juvenile emigrant population Estimates	Standardized habitat surveys-sampling
John Day Lower North Fork	17070201	John Day	X				
John Day Upper North Fork	17070201		X				
Lower John Day	17070201		X				
Upper John Day	17070201		X				
John Day South Fork	17070201		X				
John Day Middle Fork	17070201		X				
Chiwawa River	17020011	Wenatchee	X			X	X
Icicle Creek	17020011		X			X	X
Wenatchee River	17020011		X			X	X
Alturas Lake Creek	17060201	Upper Salmon	X	X	X		
Beaver Creek	17060201		X	X	X		
East Fork Salmon River	17060201		X	X	X	X	
Valley Creek	17060201		X	X	X		
West Fork Yankee Fork	17060201		X	X	X		

Table B.4. Biological variables to be monitored for tributary habitat status and effectiveness research.

Life stage	Monitoring variable	Sampling frequency (all measured annually)
Adults	Redd or weir counts	Multiple counts within spawning season
	Age class of spawners	Multiple counts within spawning season
	Hatchery fish spawning wild	Multiple counts within spawning season
Juveniles		
	Parr density/size	Single snorkeling sessions during summer/fall
	Parr PIT tagging/size	Single tagging sessions during summer/fall
	Resident parr abundance (mark-recapture)	Single tagging sessions during summer/fall
	Emigrant parr and smolt abundance/size	Screw trap sampling during fall and spring out-migration, with mark-recapture to estimate trap efficiency

Table B.5. Action types and assessments as to effects on presence-absence and density.

Action Type	Change in presence-absence	Increase in current (non-zero) density
Instream flows	No, unless low flow is very low	Maybe
Nutrient additions	No	Maybe, if juveniles leave because of limited food supply
Barrier removal	Yes	No, unless current barriers are partially passable
Diversion screens	No	No
Sediment reduction	Maybe, if treated area is so heavily embedded that spawning is impossible	Maybe – removing sediment may increase spawning usage
Riparian buffers	No, unless area is currently uninhabitable due to lack of cover	Maybe – treatment may attract juveniles to improved habitat
Instream structures	No, unless area is currently uninhabitable due to lack of structures	Maybe – treatment may attract juveniles to improved habitat
Water quality improvements	No, unless temperature or chemicals render area uninhabitable	Maybe – treatment may attract juveniles to more hospitable habitat

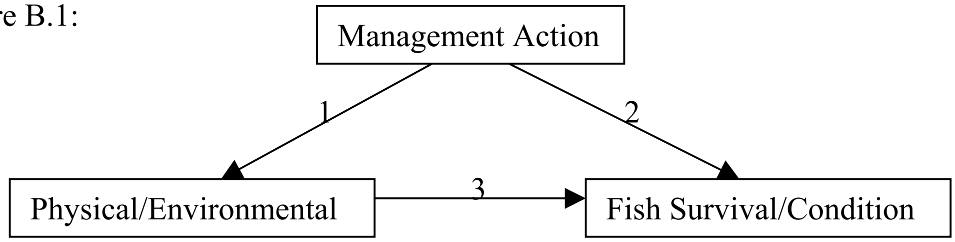
Table B.6. Physical/environmental indicator variables to be monitored for tributary habitat status and effectiveness research. Table is modified from Hillman and Giorgi (2002).

General characteristics	Specific indicators	Recommended protocols	Sampling frequency	Spatial density/locations
Temperature	MWMT and MDMT	Schuett-Hames et al. (1999a); Zaroban (2000)	Continuous	Lower end of treatment and control reaches
Sed/turbidity	Turbidity	OPSW (1999)	Seasonal (4 times/yr)	As above
	Depth fines	Platts et al. (1983); Schuett-Hames (1999b)	Annual	Three subsamples within each spawning area (pool tailout or riffle)within a site
Contaminant/ nutrients	pH	OPSW (1999)	Seasonal (4 times/yr)	Lower end of treatment and control reaches
	DO	OPSW (1999)	As above	As above
	Nitrogen	OPSW (1999)	As above	As above
	Phosphorus	OPSW (1999)	As above	As above
Artificial barriers	Road crossings	Parker (2000); WDFW (2000)	Annual	Total number for entire reach
	Diversion dams	Bain & Stevenson (1999); WDFW (2000)	Annual	As above
	Fishways	WDFW (2000)	Annual	As above
Substrate	Dominant substrate	Bevenger & King (1995); Bunte & Abt (2001)	Annual	Measured at 11 equally space transects in each site
	Embeddedness	MacDonald et al. (1991)	Annual	Three subsamples within riffles used for spawning and rearing within a site
Large wood	Pieces per mile	Overton et al. (1997); BURPTAC (1999)	Annual	Total number for entire reach
Pools	Pools per mile	Overton et al. (1997); Platts et al. (1983)	Annual	As above
	Pool quality	Platts et al. (1983)	Annual	Measure each pool within survey sites
Off-channel habitat	Side channels and backwaters	WFPB (1995); Reeves et al. (2001)	Annual	Total number for entire reach
Channel condition	Width/depth ratio	BURPTAC (1999)	Annual	Measured at 11 equally spaced transects in each site
	Wetted width	Bain & Stevenson (1999)	Annual	As above
	Bank full width	Bain & Stevenson (1999)	Annual	As above
	Bank stability	Platts et al. (1987); BURPTAC (1999)	Annual	As above
Streamflows	Streamflow	Bain & Stevenson (1999); MacDonald (1991)	Continuous	In lower reach for each major tributary
Watershed condition	Watershed road density	WFC (1998); Reeves et al. (2001)	Annual	Entire watershed
	Riparian-road index	WFC (1998)	Annual	Entire watershed
	Equivalent clearcut area	USFS (1974); King (1989)	Annual	Entire watershed
	Percent veg altered	Platts et al. (1987)	Annual	Measured within each sampling site

Table B.7. Draft schedule for tributary effectiveness M&E

Year	Month	Event
2003	January	Start habitat action and biological data inventory
		Top-down approach out for comment
		Begin CBFWA consultation on monitoring details
		RFPs for extensive habitat surveys out
		Top-down approach comments back
	February	Complete CBFWA consultation
		Top-down approach out as final
	March	Complete habitat action and biological data inventory
		RFPs for extensive habitat surveys back to BPA
		Select contractors for extensive surveys
		Identify gaps in biological monitoring (e.g., no smolt enumeration for sub-populations X, Y, and Z). RFPs for additional monitoring (e.g., smolt traps, spawner surveys, etc.)
	April	Identify treatment and control sites
		Note: this means control sites cannot be chosen based on similarity to treatment sites
		Decide on scope (number of treatment and control sites) for intensive habitat surveys
	May	Hire and train extensive surveyors
		Let contracts for additional biological monitoring.
	June	Begin field work
	September	Field work complete
	October	Complete compilation of surveys

Figure B.1:


Management Action
1
2
3
Physical/Environmental
Fish Survival/Condition

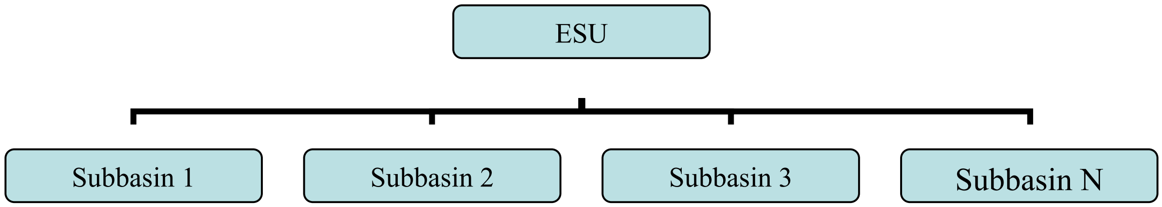


Figure B.2A. ESU and subbasin scale

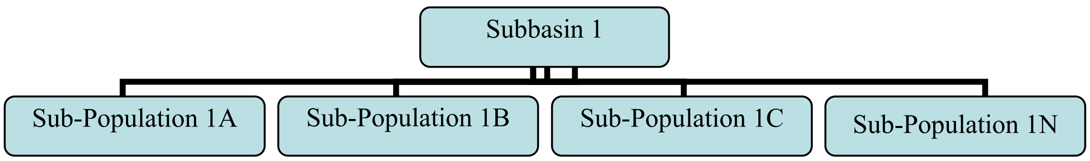


Figure B.2B. Subbasin and sub-population scale

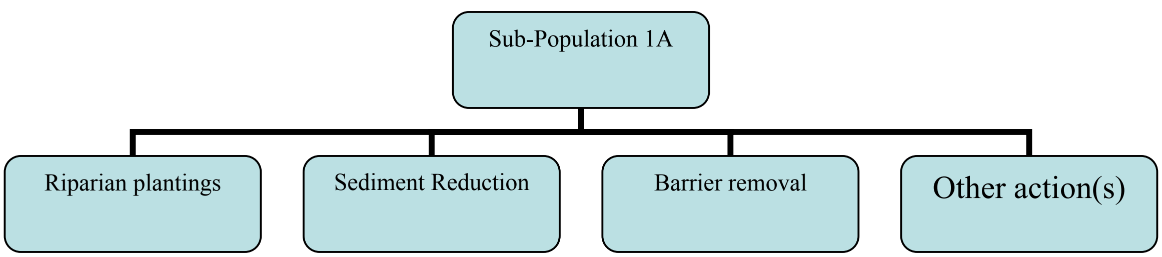


Figure B.2C. Sub-populations and action scale. Action sites may be scattered throughout the sub-population's spawning and tributary rearing range.

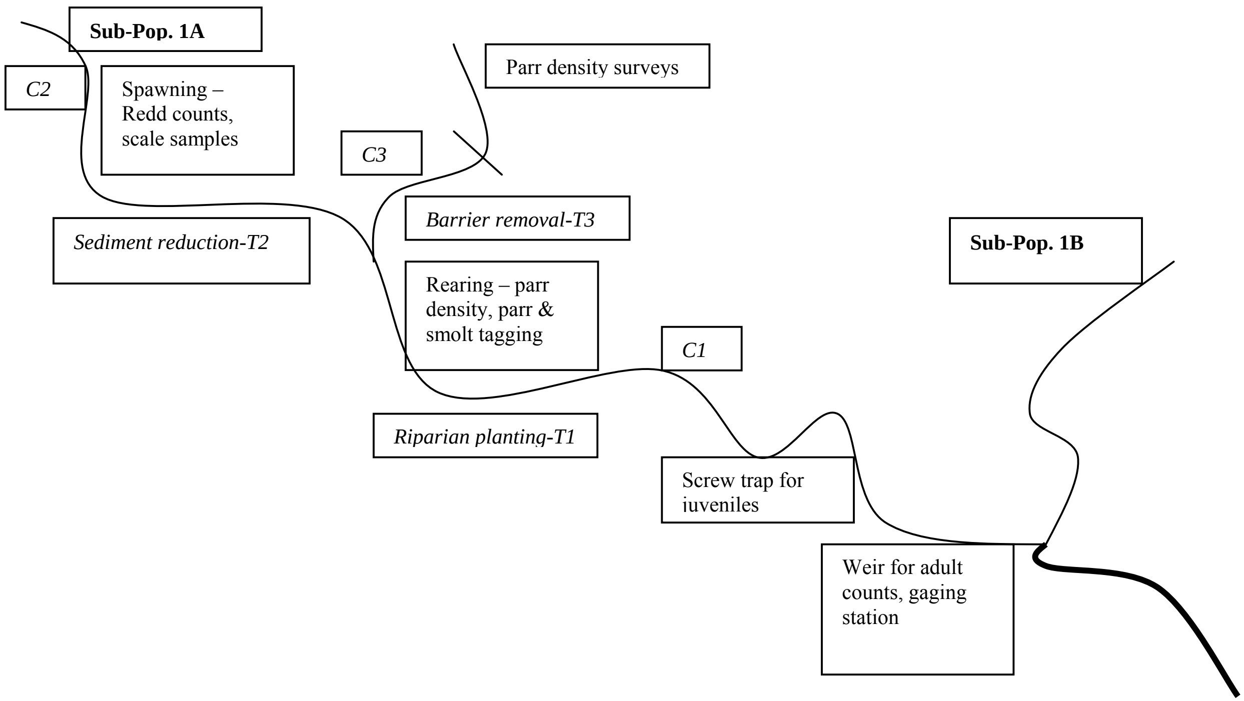


Figure B.3. Example sub-population, showing layout of actions and sampling sites. Biological monitoring locations are in regular type, action and control locations are italicized. "T(n)" denotes sites for intensive monitoring at treatment sites, "C(n)" similar monitoring for control sites.

C. Appendix C: Hydro-system Workgroup Plan

(1) Introduction

This plan addresses RME issues that are directly associated with the FCRPS hydrosystem, particularly with respect to effects on life stages directly impacted by the dams and their operation. The objectives of the activities specified in this plan are to:

- Satisfy hydro-related RME RPAs presented in the FCRPS BO, and
- Develop an approach for evaluating progress toward and compliance with survival performance standards specified in the BO.

The three principal RME categories treated in this plan correspond to RME Strategies formulated in the Implementation Plan elements. Specifically, those Strategies are Status Monitoring (Strategy 1), Effectiveness Monitoring and Research (Strategy 2), and Critical Uncertainty Research (CUR) (Strategy 3). In this plan, Strategy 2 is referred to as Action Effectiveness Research.

Participants: This plan was developed by the RME Hydro Work Group (HWG) comprised of representatives from the Action Agencies and NMFS. Core members include Bill Hevlin, John Williams, Bill Maslen, Rock Peters, Marvin Shutters and Al Giorgi (facilitator). To date, technical contributors include Steven Smith, Rich Zabel, Dave Clugston, John Skalski and some of his staff from the University of Washington.

In the hydro-corridor, the focus of Status Monitoring is to document the survival of juveniles and adults within the FCRPS, and general environmental conditions (IP sub-strategy 1.3). The BO specified target values or performance standards for survival that NMFS deemed necessary to achieve recovery. Part of status monitoring will include testing compliance with those survival standards.

Assessing the effectiveness of hydro-system actions, project reconfigurations and operations is called for under IP sub-strategy 2.3. These field studies focus on structural changes and operations occurring at individual projects. The vast majority of these are deigned and conducted under the COE Anadromous Fish Passage Evaluation Program. This plan does not treat those specifically, but relies on the established program to plan that collective research.

Within the hydro-corridor, critical uncertainty research focuses on two key uncertainties as described in IP sub-strategies 3.3 and 3.4. The research called for under those sub-strategies is meant to resolve important issues related to delayed effects associated with transporting smolts (D), and extra mortality attributable to passage through the hydro-system or different routes in the system that may be expressed in-river or following seawater entry.

The RME RPAs from the FCRPS BO that are addressed in this plan are summarized in Table 1.

Table 1. RME RPAs identified as Hydro-related in the FCRPS BO. A brief descriptor accompanies each one.

RPA	Description
185	Calculate D
186	Determine where D-mortality is expressed
187	Examine the relation of D to timing of seawater (estuary) entry
188	Investigate hydro system (delayed) effects on stock productivity
189	Study effects of passage history on SAR
190	SRFC- early life history
191	Improve year-round adult counts
192	Install adequate # of adult detectors
193	Investigate new tagging systems
195	Estimate and geographically partition post-Bonneville smolt mortality
199	Hydro Research Actions (RA) – Appendix H of 2000 BiOp

Plan Elements
In this plan we (Hydro Workgroup):

- Identify key performance indicators and standards. Performance indicators are responses or conditions that are monitored. They are either biological or environmental.
- Assess research and monitoring needs – gap analysis. This involves a description of RPA requirements, RME projects satisfying each RPA, the identification of deficiencies and recommended remedies.
- Present guidelines for conducting RME, if applicable.
- Status Monitoring
  - Recommend approaches for conducting the required RME.
  - Identify options for testing progress towards and compliance with numerical standards presented in the BO.
- Critical Uncertainty Research
  - Describe project coverage of CU RPAs.
  - Assess the connection between RPA expectations and true research capabilities.
  - Offer recommendations if disconnects are apparent
- Action Effectiveness Research- is briefly treated. Defer to the AFEP planning process.

(2) Performance Standards and Indicators

FCRPS performance standards (PS) for the hydro-system are prescribed in section 9.2.2 and 9.2.3 of the 2000 FCRPS Biological Opinion. There are two general categories of PS: survival rates and physical/environmental conditions. The monitoring of life stage survival and environmental conditions through the FCRPS constitute status monitoring as prescribed in the BO.

Physical performance standards (BO Section 9.2.3) are further described in BO section 9.6.1. These take the form of guidelines for operating the system. They include flow targets and spill schedules. The BO does not call for specific tests to determine compliance with the guidelines, nor does is call for additional mechanisms to monitor these beyond procedures already in place. So, this plan does not treat this further.

Life stage survival standards – The most specific performance standards are those expressed in the form of life stage survival estimates for juvenile and adult life stages (Section 9.2.2.2.1). Table 9.2-3 of the BO lists those PS. Survival rates are specified by ESU over the geographic expanse of the FCRPS that each ESU encounters. Several types of survival standards are identified for adult and juvenile salmonids (Table 2). These include (1) a combined survival that includes transport, in-river and delayed effects incurred by transported ESUs, (2) survival experienced in-river while passing the complex of dams and, (3) survival past individual projects (dam and pool).

Table 2. Performance standards that apply to either juvenile or adult salmonids migrating through the FCRPS. The asterisk indicates that these stocks are not currently transported, however strategies may change in the future at which time combined survival would be the preferred performance standard.

Life Stage	Combined survival w/ D	System Survival (in-river)	Per Project Survival
Adult	NA	All ESUs	All ESUs
Juvenile	Snake and *Upper Columbia	All ESUs	All ESUs

The BO did not formally specify which type of PS is preferred for application to a particular ESU. However, a footnote in that BO table implies that the per-project PS may have limited applicability and the other two carry more weight.

The survival performance standards represent the best passage survivals the Biological Effects Team felt could be realized if the hydro RPAs were successfully implemented. Juvenile standards were derived using SIMPAS. Reach survival estimates used in the exercise were a combination of empirical and extrapolated values. Also, the analysis used some empirical and assumed default values for passage route survivals and efficiencies.

Adult survival standards were based on the assumption that the base case system survival for Snake River salmonid stocks could be increased by 3 percentage points. This equated to approximately 0.5 percent per project, a value applied to other ESUs.

With respect to the juvenile standards, the workgroup has been deliberating whether it would be advisable to update standards originally reported in the BO. NMFS representatives are discussing the situation with their managers to determine how to resolve this matter.

Indicators

The indicators for survival monitoring are inherent in the standards; estimates of smolt and adult survival are required. However, the nature of the survival estimates may be ESU-specific. Thus, in the Action Plan the HWG selects the preferred type of estimate for each ESU. Preference is dictated by the management needs as well as the practicality of generating a representative survival estimate for the ESU of interest. These issues are detailed in the following action plan section of this document. Additionally, performance measures or indicators associated with

CUR include in-river survival estimates, as well as estimates such as SAR, TIR, and D. Again, details are treated in a later section.

(3) RME needs

General RPA requirements – In the 2000 FCRPS BO, Research monitoring and evaluation efforts are identified in RPAs. Some of those deal specifically with hydro-related RME matters. That subset appears in Table 1. Members of the AA-NMFS Hydro Workgroup reviewed the coverage each RPA was getting in terms of extant and planned research. Where gaps were identified, recommendations are offered to rectify the situation.

Research Actions – One RPA (#199) details a number of specific Research Actions. These are described in Appendix H of the BO. Some of these are redundant with RPAs, but provide more detail on some points. Most refer to specific types of estimates (FPE, survival etc.) that need to be obtained at different dams. Others focus on migratory behavior, and general smolt monitoring. All of these (25) appear appropriate for review by the Hydro Group. However, many are funded under the COE AFEP program and undergo formal review in that forum. The Hydro work group (HWG) assumed those have been deemed to be satisfactory with respect to BO compliance, since NMFS actively participates in that process and conducts much of the research. There are other projects that are funded under the NPPC FW Program, which may not have received as much BO-related scrutiny. The HWG will focus on those, particularly those submitted under the mainstem and system-wide province.

There are numerous additional RPAs that involve hydro-related issues, but those lie outside the bounds of this RME-specific set (RPA #179-199). Most of those are in the form of directives to fix or change some operation or structure at dams. These fall under the category of AER. They are treated under the AFEP and the interagency System Configuration Team and are not treated here.

RME projects, Overview – A key part of the RME assessment involves a gap analysis that identifies omissions or deficiencies in planned or ongoing research and monitoring. The work group has conducted an assessment for the hydro-related projects. The overview here only indicates whether RME is being conducted and is generally related to the RPA goals. A more detailed evaluation of gaps by RPA immediately follows this overview.

Thus far, parties from the COE, BPA, and NMFS have reviewed all hydro-related RPAs and provided this assessment. The group adapted Appendix Table 5 from Fisher (2002) for this task. They classified RME projects/proposals as status monitoring, action effectiveness research, or critical uncertainty research (Table 3).

Table 3. Funding agencies assessment of RME actions in the form of projects or proposals that cover RPA topics.

RPA	Description	Funding Agency	RME Category	RME Actions
185	estimate D	COE	CU	Ongoing
186	Determine where D-mortality is expressed	COE	CU	Ongoing
187	D - timing of seawater entry	COE BPA	CU	Ongoing
188	EM Hydro-related	COE BPA	CU	Proposed
189	passage history - SAR	COE	CU	Ongoing
190	SRFC - early life history	BPA	SM	Ongoing
191	Improve adult counts	COE	SM	no specific project, but part of established COE adult counting program
192	Install adult detectors	COE BPA	SM	Ongoing
193	new tagging systems	COE BPA	SM	Ongoing
195	Partition Post-Bonneville mortality	COE	CU	Ongoing and Proposed
199	Hydro RME-related RAs – Appendix H in the BIOP	COE BPA USBR	AER, SM	Ongoing or Proposed for most if not all RME-related RAs

The workgroup further identified hydro-related research projects and the RPAs that they are linked to in Table 4. This only indicates that work is being done on the RPA topic, not that the research is entirely satisfying the intent of the RPA. It would be inappropriate to expect that any single research project could completely resolve the issues stated in any particular RME-RPA.

Table 4. Hydro-related RME-RPA coverage by project, as indicated by the project sponsors, or as recognized by the RME work group. Coverage does not imply adequacy for satisfying intent of RPA, only that research is being conducted on the general topic matter of the RPA. List includes ongoing projects as well as proposals submitted for 2003 research. Yellow highlighting indicates projects that have hydro linkage, but were more fully addressed by other work groups, particularly by the estuary and population status monitoring workgroups.

	RME RPAs- Hydro										
Project	**185**	**186**	**187**	**188**	**189**	**190**	**191**	**192**	**193**	**195**	**199**
NPPC F&W Program											
199302900 NMFS PIT survival	X		x		x	x			x		x
199602000 CSS	X		x	x	x						x
35047- EM experiement				x						x	x
198331900 new tag methods					x			x			x
199900301- fall/chum spawning monitoring below BON											x
199102900-USFWS – SR falls-FlowAug						x					x
35025- FCRPS-plume			x								x
35031- tag coordination committee											x
35046- plume use – micro acoustic tag		x							x	x	x
1997-024-000 – avian predation		x								x	x
2001-003-00 – adult PIT detectors								x			
199008000 – PTAGIS	x		x		x	x			x		x
199102800 – wild tagging NMFS	x		x	x							
199403300 – FPC	x				x	x					x
198712700 – smolt monitoring	x				x	x					x
1989107001 – Statistical support UW	x				x	x					x
19105100 – Statistical support UW	x				x	x					x
COE-Funded											
Tpe-w-00-1 NMFS transport Snake and Mcn	x	x	x					x			x
BPS-00-11 Bird PIT		x	x							x	x
Est-02-3 timing est.			x								x
Tpe-w-00-2 barge post release survival		x									x
EST-P-01-NMFS acoustic tag				x					x	x	x

	RME RPAs- Hydro										
Project	**185**	**186**	**187**	**188**	**189**	**190**	**191**	**192**	**193**	**195**	**199**
BPS-W-00-10a, D in estuary and plume		x									x
BPS-W-00-9b migration histories		x			x						x
BPS-W-00-9a physiology and bypass history					x						x
TPE-W-00-1c physiology and transport		x			x						x

This general survey indicates that all hydro RME-RPAs are being actively pursued at some level. It does not provide a clear indication whether the research and monitoring is adequate to satisfy the full intent of each RPA. For that a more detailed gap and adequacy assessment follows. This survey indicates that every RPA except one (191) is being addressed by more than one research effort.

(a) Status Monitoring - Survival through the FCRPS

RME Needs – RPA Directives: The BIOP presents specific survival standards that smolts and adults should ultimately achieve once the FCRPS is entirely upgraded with respect to fish passage (section 9.2.2.2.1 of the BIOP; table 9.2-3). However, none of the BIOP RPAs specifically refer to the need for acquiring the estimates necessary to test compliance with those standards. To test whether survival standards (juvenile and adult) are being achieved requires annual empirical estimates of survival. However, a number of RPAs and associated RAs request that certain survival estimates be obtained. These have the potential of being useful in quantitative tests at the check-ins. At this juncture life stage survival standards extend to the tailrace of Bonneville Dam. Estimates of D are also required if total effects are to be incorporated into check-in evaluations. RPA 185 directly requests that estimates of D be provided for ESUs that are transported. To satisfy that, RPA also requires that estimates of in-river survival are available.

Current projects/proposals: Smolt survival – At least four projects are either underway or proposed, which will generate in-river survival estimates for smolts over long river segments, using PIT tags (199302900, 199602000, 35047 and TPE-W-00-1). In addition researchers at NMFS and USGS are using radio tags to estimate project survival at selected dams in the lower Columbia River. These also may have utility as indicators for PS testing.

Adult survival – The COE funds a broad-based adult passage study at the Universty of Idaho and NMFS. That study has the capacity to generate estimates of minimum survival for species radio-tagged in any given year. However, the COE has suggested that such estimates may not be available every year. Alternatively PIT-tag based survival estimates offer new opportunities that may be realized with the installation of adult detectors at strategic sites by 2003. Also, stock-specific estimates may soon be available by combining radio and PIT technologies.

Gap and adequacy assessment: Clearly there are a variety of projects that are producing survival estimates in the mainstem. All of these studies employ state of the art technologies and survival estimation protocols. However, it is not possible to determine whether these projects will generate a suite of survival estimates that will be entirely adequate to satisfy BO requirements.

The difficulty lies in the vagueness of the BO with respect to specifying quantitative tests envisioned at the check-ins, and statistical properties of key estimates.

Closing the Gaps: The gap is basically the absence of clear direction describing how progress and compliance with PS will be assessed. The solution will involve an analytical exercise to be conducted by the Hydro Work Group. That process is underway, and findings to date are reported in this action plan. The workgroup contends that empirical, rather than model-based estimates, be used to evaluate progress and compliance whenever possible. As members of the RME Work group, NMFS analysts are proposing specific hypotheses, quantitative tests, rejection criteria and power analyses to focus this effort. Specifying these elements will be critical task in the execution of this RME Plan.

(b) Other Monitoring Needs and Programs - FCRPS

RME Needs-RPA Directives: Some RPAs (190,191, 192, and 193) call for information and actions that either support or can contribute to improving survival estimates necessary for hydro status monitoring, or other related estimates. For example, RPA 192 calls for increasing the number of adult PIT detectors. The expansion of the detection system affords new and improved opportunities for estimating passage survival of adults. Similarly RPA 191 calls for improving adult counts at dams. The direct linkage to adult survival estimates is less apparent, but satisfying this RPA may contribute to improving population status monitoring for some stocks. RPA 193 requests that research be directed at improving and developing new tagging and detection systems to enhance monitoring and evaluation capabilities related to survival estimation. RPA 190 is more general than others in this category. It directs the AA to provide better information describing early life history and requirements of Snake River Fall Chinook. This RPA was designated as a status monitoring action by the HWG, because it did not clearly fall under the AER or CU categories, and juvenile survival profiles are a component implied in the RPA.

Snake River Fall Chinook early life history (RPA 190)

Current projects and proposals: Two projects are collecting information and generating estimates that pertain to RPA 190 (SR Fall Chinook); 199302900 (NMFS) and 199102900 (USFWS). The NMFS study is ongoing work that generates survival estimates for hatchery fall chinook above Lower Granite Dam and through part of the FCRPS. The USFWS project is also an ongoing research effort that describes a variety of early life history characteristics of fall chinook in both the Snake and Clearwater drainage. In addition to these studies, a Snake River fall chinook transportation study was initiated in 2001 and will continue for some years. Although primarily a passage strategy study, insights regarding early life history will no doubt accrue.

Gap Assessment: Collectively the two research projects focusing on fall chinook appear adequate in terms of scope and intensity to satisfy the intent of RPA 190. Research reports extending back nearly a decade are providing quality information describing rearing and migratory characteristics of this stock. Although the survival estimates rely on hatchery stock from Lyons Ferry, opportunities to generate robust estimates using wild fish are very limited.

Recommendations for Filling Gaps: The Hydro Work Group determined the early life history research was adequate to satisfy the intent of the RPA.

Improving year-round counts for adult salmonids at dams (RPA 191)
Current projects and proposals: RPA 191 involves expanding an existing COE adult counting program and does not require a specific project. These activities fall under the auspices of the established COE Fish Passage Program.

Gap Assessment: According to the RPA the need is to expand the coverage period for enumerating adult passage at dams. Extending the adult ladder counting period into the winter is requested as is documenting fall back through the juvenile facilities, particularly at McNary. The direct linkage to adult survival estimates is less apparent, but satisfying this RPA may contribute to improving population status monitoring for some stocks.

Recommendations for Filling Gaps: COE representatives on the HWG indicated that they are discussing opportunities to improve adult counting procedures with NMFS.

Increase Adult PIT tag detection capabilities (RPA 192)
RPA 192 calls for increasing the number of adult PIT detectors. The expansion of the detection system affords new and improved opportunities for estimating passage survival of adults. Project 2001-003-00 addresses needs expressed in the RPA.

Gap Assessment: The project scope as submitted to the NPPC appears to adequately satisfy the needs expressed in the RPA. The project plans on expanding of current PIT-tag interrogation technologies for adult PIT detection in fish ladders (RPA Actions 50 and 192).

Recommendations for Filling Gaps: No gap is apparent.

Investigate feasibility of novel tagging/detection systems (RPA 193)
Current projects and proposals: RPA 193 requests that research be directed at developing and applying new tagging and detection systems to enhance monitoring and evaluation capabilities related to survival estimation. Two projects address this RPA. One (198331900), which includes the development of a high-Q detection system, is funded by the NPPC Fish and Wildlife Program. The other is a proposal submitted by NMFS to the COE (EST-P-01-nmfs).

Gap Assessment: Both projects address the RPA satisfactorily. However, there is no way to predict whether these design/development projects will be successful in producing a tag or detection system that adequately meets the specifications presented in the RPA. Those specifications are general, but demanding. They include the capability to discriminate between hatchery and wild fish, differentiate population and their use of different geographic marine areas. It is not clear that any tool can satisfy all these requirements. The implication is that the tool has marine tracking capability. However, other text in the RPA is more generic implying in-river estimates are also of interest. The gap here is the lack of clear direction offered in the RPA. Even so, in combination the two NMFS projects coverage appears adequate.

Recommendations for Filling Gaps: The HWG recommends the RPA be recast to provide clearer direction to investigators, with respect to applications envisioned by the managers.

(c) Hydrosystem - Action Effectiveness Research
RPA 199 directs the AA to fund a variety of research actions (RA) that are largely action effectiveness research projects. The gap analysis conducted by Fisher (2002) lists these RAs in

his appendix Table A8. Each of these RAs has at least one research or evaluation project associated with it. Coverage is complete. Since the COE funds these projects, the adequacy of the research is assessed through the AFEP forum. The RME work group relies on that technical forum to establish focused research projects.

(d) Critical Uncertainty Research

There were two critical uncertainties that emerged in the CRI BIOP analysis that are linked to FCRPS effects on listed stocks: the extent of delayed effects associated with transporting smolts (D), and the existence and extent of extra mortality (EM) associated with smolt passage in-river.

D (RPA 185, 186, 187)

RME Need-RPA Directives: Delayed mortality associated with transporting smolts is a critical uncertainty explicitly identified in the BO. The BO drafted no less than three RPAs (185, 186, and 187) directed at resolving key issues associated with D. RPA 185 requests expanding marking efforts with the intent off improving and refining estimates of D. Current estimates have several deficiencies most notably including poor precision and limited stock coverage. Research needs to improve on these points. RPA 186 requests that research also focus on identifying the causes of D, as well as the geographic zones where delayed effects are expressed. RPA 187 gets even more focused requesting research to assess the effects of ocean entry timing on the magnitude of delayed effects. This complex of information will prove challenging to acquire. Obtaining reliable estimates of D is critical to resolving key assumptions inherent in population modeling and extinction risk assessments.

Current projects and proposals: Three projects address key aspects related to D; Tpe-w-00-1 (NMFS transport Snake and McN), 199302000 (CBFWA - Comparative Survival Study), 199302900 (NMFS in-river survival).

Gap and adequacy assessment: Survival estimates for transported and in-river groups are necessary to calculate D. All of these projects generate such estimates using a variety of hatchery and, wild and run of river stocks through different river segments. Our review of the NPPC proposals raised the issue as to whether the precision and stock coverage proposed by the investigators would ultimately be satisfactory to conduct performance tests at the check-ins for both hydro survival and population growth rate standards. The hydro and status monitoring work groups have not resolved this as yet. The same concerns may exist for the COE transport study (tpe-w-00-1), although neither work group has reviewed that proposal with respect to the statistical properties of projected estimates of D.

Recommendations for Filling Gaps: The Hydro Work Group needs to provide the community with an assessment regarding the adequacy of D estimates emanating from these studies with respect to ESU coverage, statistical properties of the estimates, and reliance on estimates derived from hatchery fish. The latter is critical because hatchery stocks are likely the only groups that can be tagged in sufficient numbers to provide D estimates with suitable precision.

EM (RPA 188, 189, and 195)

RME Need-RPA Directives: The BO clearly identifies extra mortality (EM) as a critical uncertainty requiring resolution. This is necessary to improve population modeling analyses used in extinction risk assessments. Concerns regarding the existence and magnitude of delayed effects associated with exposure to the hydro system are of particular interest. This need is generally expressed in RPA 188, which calls for PIT-tagging of lower river stocks to use in comparisons with upper river stocks currently being PIT tagged. Related RPAs include 189 and 195 where objectives are more specific. RPA 189 focuses on establishing the cause and effect of particular passage routes on existence and magnitude of extra mortality. RPA 195 directs investigators to determine the geographic zones where post-Bonneville mortality is expressed, and the magnitude in each zone. Furthermore, the research should be designed to distinguish between natural and anthropogenic-based mortality as associated with such factors as hydro passage experience or general fitness of the stock monitored. Also, expression of any perceived extra mortality could extend well into the marine environment. Overall, this RPA is onerous in its demands and probably unrealistic with respect to expectations.

Current projects/proposals: Projects directed at estimating or identifying causes of EM include 35047 (NFMS-Extra Mortality), 199302000 (CBFWA - Comparative Survival Study), and 199302900 (NMFS- In-river Survival). Other projects that are generally related to EM issues include 35046 (Plume Use by Salmonids), 1997-024-000 (Avian predation), and EST-P-01 (Acoustic Tag System Development).

Gap Assessment: Although three project/proposals address important issues associated with EM as related to hydro-system experience, it is not clear that they individually, or collectively, satisfy the primary intent of RPAs 188, 189 and 195. The proposal that focuses most clearly on hydro-related EM is 35047. The objective of that project is to quantify delayed effects associated with passage through the hydrosystem. In their proposal review, the RME work group expressed concerns regarding the ability to consistently obtain satisfactory numbers of fish to tag, as required in the experimental design. However, the ISRP expressed more substantive concerns regarding the suitability of the design for resolving the central hypothesis. The RME work group's review of 199302900 found the effort limited in scope relative to assessing delayed effects associated with different passage routes (RPA 189). The proposed research will contribute estimates of survival associated with screen-bypassed fish, but not other routes separately. The review of 199602000 suggested power analyses were warranted, before the value of resulting inferences regarding EM could be assessed.

Overall, the collective EM-targeted research projects will likely fall short of the expectations and needs expressed in the BO. In addition the issues with addressing EM for hypothesized hydro system effects, there are no studies addressing the other non-hydro hypotheses for EM.

Recommendations for Filling Gaps: It is difficult to ascertain whether the collective research will adequately satisfy the full intent of the RPA. We suspect it may not. However, any shortcoming appears not to be associated with the capability of the research community, but rather the unreasonable nature of the requests and expectations posed in the BO under this RPA. Even so, the collective research will expand our understanding of delayed effects associated with dam passage, but not necessarily resolve all outstanding EM issues identified in the BO. To fill the gap between expectations and feasibility the managers who drafted the RPA and researchers who are attempting to satisfy it, need to discuss and resolve the apparent disconnect. In addition, there is a need for solicitation of additional studies for EM that address other hypotheses beyond hypothesized hydro system effects.

This disconnect was most apparent with respect to project 35047. The work group deliberated the strengths and weaknesses of this study exhaustively. Although there was not clear consensus whether to recommend funding, the majority of work group members endorsed the study at the December, 18, 2002, meeting. They felt that the study design was probably the only practical way to attempt to detect any delayed mortality associated with dam passage. They acknowledged that since only a few dams were included in the assessment, inferences to passage through the entire FCRPS will be limited. Even so, they felt this was the only attempt proposed thus far that may provide some insight into the hypothesized Extra mortality associated with dam passage.

(4) Action Plan (what and how to conduct Hydro RME activities)

(a) Monitoring Survival (Status Monitoring)

The objective of monitoring activities in the hydro corridor is to assess progress toward and ultimately achieving the life stage-specific survival performance standards prescribed in the BO.

ESU-specific monitoring: To accomplish this, for each ESU the work plan identifies appropriate:

- Performance standards,
- Experimental protocols (including tools) and analytical models, and
- Populations to be used as experimental or index groups.

Performance Tests: Additionally, the plan specifies a suite of analytical/statistical performance tests that can be used to assess progress towards, and compliance with survival standards. Analysts from NMFS and the University of Washington contributed to that effort.

Survival Standards: The BO identified three classes of smolt survival as candidate performance standards:

- Project (dam and pool),
- System (in-river through the FCRPS), and
- Combined, which includes survival of smolts migrating in-river, as well as those transported, and includes an estimate of any delayed transport effects (D)?

For each ESU, the plan identifies a primary survival performance standard that would be the most useful in gauging the status of that population unit. When the primary standard proves to be too limiting or impractical to obtain, then alternative standards and associated performance measures are proposed.

As of December 2002 the work group has focused on the juvenile life stage for Snake River spring/summer chinook and steelhead. This effort has proved more demanding than expected, and several important issues are still unresolved. Those include settling on reliable and useful D-estimates and crafting performance tests for the check-ins that are definitive. Here we report progress to date on those Snake River stocks.

Status Monitoring – other ESUs: The HWG has yet to address status monitoring requirements for the juvenile stages of other listed ESUs. Also, adult status monitoring options have been generally discussed but a recommended course of action has not been established.

Critical Uncertainty Research: The HWG has discussed issues regarding the estimation of D and EM, and related research. However, the group has not yet resolved how and which estimates are most appropriate for application in performance tests, nor have they determined if the existing and proposed body of research will adequately satisfy the expectation stated and implied in the BO.

Many of the issues that have surface during our deliberations will need to be discussed and clarified with the authors of the BO and upper level managers in order to construct a plan acceptable to all parties involved. Thus, we expect this version of the plan will not be completed until the spring of 2003.

(b) Snake River ESUs

Spring/summer chinook and steelhead

Performance Standard
Since these two ESUs are subjected to transport at Snake River dams, the primary PS is the combined survival for in-river and transported fish. To calculate this value on an annual basis requires that a suite of performance measures be acquired each year. These include estimates the following:

- In-river survival from the head of LGR pool (ideally) to the tailrace of Bonneville Dam
- Direct transport survival from collection through liberation
- D- delayed effects associated with the transportation process

Experimental protocols and models
In-river survival estimates should remain consistent with those calculated and reported by NMFS since 1994 (See Attachment1). Those estimates are based on a single release model and PIT tag data obtained through the FCRPS. Some of the existing survival estimates from LGRpool-BONtailrace are solely based on empirical estimates. Others are a combination of empirical and extrapolated estimates.

However, there are concerns about extrapolating, or applying, empirical estimates derived in the Snake River to the lower Columbia River. Zabel et al. (2002) compared empirical estimates obtained through both reaches in 2001. They reported that per mile survival of both Snake River stocks through the lower Columbia projects was lower than that estimated through the Snake River. This has important implications to the BO performance standards, since the extrapolation approach was used to establish survival standards cited in the BO. Thus, those standards may be in question, given the information developed by NMFS analysts since the printing of the BO. The Hydro Work Group has no authority to revise performance standards. But we have the obligation to point out that existing standards may inappropriately estimate the survival potential through the hydrosystem.

Since 1997 it has been possible to empirically estimate survival over increasingly longer reaches of the FCRPS, particularly through the McNary to Bonneville Dam reach (Williams et al. 2001). This has been a consequence of increased sampling capability in the lower river, especially at Bonneville Dam and using PIT trawls in the lower river. If the activation of the corner collector at Bonneville Second Powerhouse appreciably decreases PIT tag detections at the dam, then it may be necessary to model or extrapolate survival though that reach, once again. However, this does not appear likely, because provisions are in place to equip the corner collector with a PIT detector of suitable detection efficiency.

Weighted estimates: In recent years, the general approach has been to calculate and report weighted, annual estimates of in-river survival. The plan calls for weighted estimates be reported annually in the future, in situations where they can be calculated.

Direct survival during transportation is presumed to be a constant 98 percent, but this value is based on anecdotal observations only. The HWG recommends that some effort should be expended to empirically establish the actual value. It is possible that some of the effect currently designated as D may be expressed during the transport process. This estimate can reasonably be considered an information gap requiring resolution.

D estimates (representative, accurate and precise) are the most problematic estimates to empirically obtain on annual basis. There are several complicating factors. NMFS analysts reported that wild and hatchery fish appear to respond differently to transport in terms of delayed effects (Williams personal communication). However, small sample sizes associated with wild estimates may reduce confidence in those estimates. To obtain suitable sample sizes, existing and future estimates of D my need to be based on a pooled estimate derived from hatchery and wild fish. Also, D estimates lag in-river survival estimates by 2 to 4 years. This limits usefulness for timely application at the check-ins. Investigators at the UW have developed a model that predicts annual estimates of D based on prevailing water temperature during the migration. This model can potentially predict estimates of D in a timely manner. However, the work group views this as hypothesis at this point, not a reliable means to confidently predict D for any migration year. Even so, the work group will track the UW team as they continue refining their model, which may prove useful in the future.

The HWG currently has no final recommendation as to how representative annual estimates of D can be calculated and applied in a timely manner. However we do recommend the following actions:

1. Acquire more reliable D-estimates for wild Snake stream-type populations by increasing the transported percent of PIT-tagged wild fish arriving at LGR and LGO dams.
2. By the 2003 check-in, devise a strategy which clearly describes analytical procedures regarding the application of D at the 2005 and 2008 check-ins.

Because it is not clear what values for D will be deemed to be representative and can be confidently applied at the check-ins, the hydro work group supports continuing the planned research regarding this critical uncertainty, as described later in this plan.

Populations Monitored

Existing system survival estimates (Attachment 1) are based on a composite population of hatchery and wild fish, the proportions of which can vary annually. To maintain consistency with baseline estimates, the same composite index group will be used in future assessments. Also, the HWG requests that NMFS document the stock composition (proportions) of the index population as accurately as possible and report that annually. This is necessary, because the SR model reflects not only hydro-related, but all effects influencing survival that are expressed while migrating through the FCRPS. If for example, a particular hatchery dominates the migration in a given year and exhibits extremely good or bad survival in-river due to rearing conditions, then the annual estimate could be skewed. Knowing hatchery and wild proportions could prove useful when interpreting retrospective analyses conducted at the check-ins.

Monitoring and Generating Necessary Estimates
All monitoring should continue through at least the decade following the publication of the BO. NMFS investigators will continue to conduct research activities necessary to produce the estimates identified in this plan. These include annual estimates of in-river survival and appropriate estimates of D, ideally on an annual basis. The work group will review those estimates as they are submitted and ensure they are sound and consistent with those prescribed herein. The work group has not specified what agency is responsible for estimating direct transport survival only that this need exists. The group will suggest the AFEP process should solicit proposals on this topic for 2004.

Fall chinook

Performance Standard (unresolved)
Since this ESU is subjected to transport at Snake River dams, the most informative PS would be the combined survival for in-river and transported fish. Calculating this value on an annual basis requires the same suite of performance measures cited previously for spring migrants. Unfortunately, no estimates of combined survival have ever been calculated or reported for Snake River fall chinook. Thus, no baseline estimates exist. Furthermore, there are no obvious opportunities to empirically generate such estimates. To date, it has not been possible to estimate in-river survival through the entire FCRPS. This is not expected to change in the foreseeable future. Lacking adequate monitoring capability, alternative Performance Standards may need to be considered. The HWG is exploring options with managers. As a consequence, this plan does not yet identify the preferred PS, and explores this matter in more detail explanation in the text that follows.

Experimental protocols and models (pending)
In-river survival: A major constraint to generating representative estimates of system survival through long expanses of the FCRPS, lies with the inability to empirically estimate survival past Lower Monumental Dam. All estimates published thus far only extend from upstream release sites to LOMO tailrace (Smith et al. 2002). If the work group elects to focus on in-river survival, then a shorter segment of the FCRPS may have to suffice as the most instructive response zone. At this time that response zone extends from LGR Dam to LOMO tailrace. Including survival through LGR pool may not be appropriate, since fish are still displaying rearing tendencies and quasi-resident behavior while in that river segment. Whereas, by the time fish have passed LGR they are demonstrating a clear tendency to initiate downstream passage.

This reach is considerably shorter than the target reach (LGR pool to BON tailrace) specified for in-river system survival in the BO. To characterize survival through that entire expanse will require either extrapolating or modeling survival through the lower section. The resultant system survival estimate would then be a composite of annual empirical and model-based estimates. However, analysts at NMFS are reluctant to extrapolate survival over such a long unmonitored reach. Although, the approach is consistent with the SIMPAS analysis used to originally establish the PS in the BO.

It has been proposed that in-river survival estimates will be based on the single release model using PIT data collected at sampling sites in the FCRPS, as described by Smith et al. 2002). But there are remaining difficulties with any such in-river survival estimates. They may not reflect the survival dynamics of the entire fall chinook population because:

- Some fraction of the population holds over and migrates the following spring, after incurring some unknown amount of over-winter mortality.
- Even within a year, late migrating fish are excluded from the estimate since they do not all move through the system prior to the termination of sampling at dams.
- Survival estimates are based on hatchery stock from Lyons Ferry, which have been observed to display survival very different from wild counterparts in some years. The differential survival appears to be associated with the fact that they often vary in size, disease-related mortality, and migration timing from their wild counterparts.

Collectively, these observations indicate that it is going to be difficult to accurately represent passage mortality incurred by the wild Snake River ESU, through the entire FCRPS. However, the work group recommends that two different procedures be considered as candidates for monitoring passage survival. Rely or survival estimates that:

1. Span the FCRPS, but are comprised from empirical and model-based estimates (Attachment 2)
2. Span a segment of the FCRP, but are comprised only of empirical estimates.

Adopting the first approach would enable the selection of combined survival as a performance standard if reliable D-estimates are acquired in the future.

Using the Second approach would require that a new PS reflecting survival through the monitored portion of the FCRPS be developed and adopted by NMFS.

At this juncture, this entire matter is as yet unresolved and being investigated by NMFS analysts and the hydro work group. Any final decisions are deferred at this time, but the plan is to select the preferred approach following discussions with managers at NMFS and the AA.

Direct survival during transport: As noted for other Snake River stocks, no empirical estimates of direct transport survival are available, only anecdotal observations. We recommend the presumed 98 percent survival estimate be verified experimentally, as an element of critical uncertainty research treated later in this plan.

D estimates: Reliable and representative estimates of D do not exist for this ESU. This is yet another constraint that negates the utility of using combined survival as a performance standard for fall chinook. The D value of 0.24 adopted in the PATH forum was a compromise value that is not supported by any statistically sound empirical estimates. Obtaining representative annual estimates of D will require a concerted experimental effort. NMFS investigators have embarked on that line of study. It is too early to ascertain whether the estimates will be robust enough to satisfy BO needs. Even if sound estimates emerge the same limitations expressed for spring migrants apply to this ESU.

Populations Monitored (pending)
We expect that Lyons Ferry Hatchery fish will be used to generate in-river survival and D-estimates. However, there is the need to continue wild fish PIT-tagging for use as a comparison. Tracking the performance of each group through common reaches will enable us to determine if the hatchery stock is consistently acceptable as a surrogate for the wild component of the ESU.

*Monitoring and Generating Necessary Estimates (*pending)
The HWG recommends the Snake River fall chinook transportation studies continue from 2003 to 2008. This effort could also, supply the in-river migrants for use in monitoring in-river survival.

Upper Columbia (Spring Chinook, Steelhead)

Performance Standard
The primary performance standard for Upper Columbia spring chinook and steelhead is in-river system survival from McNary Dam to Bonneville Dam tailrace. Since these stocks are rarely transported from McNary Dam, in-river survival estimates through the FCRPS (system survival at BO) are the most instructive performance measures. The system survival goal according to Table 9.2-3 in the BO is to achieve 66.4 percent and 67.7 percent through the FCRPS.

An important issue raised previously for Snake River stocks emerges here as well. Since SIMPAS model-based estimates were used to set the PS values, the standards for Upper Columbia stocks will likely need revision, as this plan pointed out for Snake River PS.

Experimental protocols and models (pending)
In-river survival: The Hydro Work Group has not yet decided how system survival will be estimated for the upper Columbia steelhead and spring chinook. There are several important considerations that factor into this decision that has not been resolved.

- First, the preferred estimates are those based on a single release recapture model using PIT tag data obtained through the FCRPS. But, future sampling capabilities at BON will in part determine the usefulness of any resulting estimates.

- The stocks selected will be a critical point as discussed below.

- No pre-2000 estimates have been compiled or even calculated for this reach of the FCRPS, so, the progress and testing protocols would necessarily differ from those adopted for Snake spring migrants.

Populations Monitored ***(pending)***: These have yet to be identified. Candidates include PIT-tagged hatchery stocks emanating in the Upper Columbia or Snake ROR composite population migrating through the MCN to BON reach. There is no wild fish PIT-tagging program currently in place in the upper Columbia. Thus, estimates for wild fish would not be available for these ESUs.

Monitoring and Generating Necessary Estimates
This activity is contingent on resolving issues mentioned previously for this ESU.

Lower Columbia Chinook and Steelhead
(To be developed and formatted as for other ESUs.)

(c) Progress and Compliance Tests

Progress: The BO only provides general guidance as to what might constitute a progress test for *juvenile* survival in 2005 and 2008. Furthermore, approaches for testing adult performance were not provided. The purpose of testing juvenile survival is to determine whether or not management actions in the hydrosystem are improving survival and advancing toward the ultimate goal, the stated survival standards. The BO proposed that two-sample tests on one-sided hypotheses be conducted. A base period was specified as 1994 to 1999 (BO table 9.7-1). The BO briefly describes the envisioned tests for juveniles, but details regarding data needs and the actual test protocols were not provided. Skalski and Ngouenet (2001) conducted a power analysis involving the two hypothesis tests proposed in the BO. They concluded that proposed test had a poor probability of correctly identifying the true state of progress or compliance. They suggest alternative decision rules be explored and considered.

Compliance: The timeline for attaining the specified PS is 10 years. However, the BO offers no guidance with respect to how attainment will be tested quantitatively. Also, there are no guidelines dictating the use of empirical data or models in monitoring.

Recently Skalski, Lady and Smith (Attachment 3) offered an approach for evaluating progress and compliance with smolt survival standards. These recent analytical efforts show that most conventional testing procedure will have limited power in testing key hypotheses pertaining to the PS. The alternative they developed involves a suite of tests. Furthermore, they suggest that even these may not be appropriate for the application and recommend that a multi-dimensional framework for testing be explored.

Discussions with NMFS fisheries managers on December 18 indicated that they felt the HWG was pursuing more statistically rigorous and complex analyses than the authors of the BO envisioned. They implied that more simplistic approaches are preferred. The work group is unclear what the purpose or implication of applying qualitative criteria and simplistic assessments are at the check-ins. We recommend the decision-makers and technical work groups convene and clarify the direction the work group should take with respect to devising testing protocols for progress and compliance.

(d) Adult Salmonid Passage Monitoring and Performance Standards
(To be developed)

(e) Critical uncertainty Research (write-up pending)

1. Estimating D for transported stocks. (Include direct survival during transport.)
2. Investigating EM attributable to passage history or timing of seawater entry.

(f) Action Effectiveness Research
These collective studies are designed, reviewed and funded under the auspices of AFEP. They are not treated separately in this plan.

(g) Literature Cited
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Attachment 1 – Smith (to be added)

Attachment 2 – Smith & Zabel (to be added)

Attachment 3 – Skalski, Lady & Smith (to be added)

Attachment 1 – Smith

Another look at in-river survival estimates for juvenile salmonids leading to performance standards in the 2000 FCRPS Biological Opinion

SUMMARY
The purpose of this exercise was to compare empirical data and SIMPAS-based estimates for recent years and to determine whether these comparisons gave information regarding the accuracy of SIMPAS-based estimates for the “pre-BiOp” period (1994-1999). For some years in the Pre-BiOp period no empirical data were available downstream from McNary Dam, so SIMPAS was used to estimate survival. These model-based estimates were then the basis for the baseline survival from which performance standards were developed, and against which post-BiOp survival estimates are to be compared to determine whether anticipated improvements are realized.

In recent years, in which both empirical data and SIMPAS estimates are available, SIMPAS estimates were, on average, 6.9 percent greater than empirical estimates for Snake River yearling chinook salmon, and 3.8 percent less than empirical estimates for Snake River steelhead. We assumed that the average relationship between SIMPAS estimates for the pre-BiOp period and what would have been obtained empirically was the same as in recent years. We adjusted the estimates in BiOp Table 6.2.-7 accordingly, and arrived at the following conclusions:

The current best estimate of the average 1994-1999 spring/summer yearling chinook salmon survival from LGR to BON is **38.7** percent, rather than the 40.8 percent in Table 6.2-7 in the 2000 BiOp.

For steelhead the 1994-1999 mean survival from LGR to BON in the BiOp was 41.5 percent, but our best current estimate is **43.7** percent.

INTRODUCTION
Table 6.2-7 of the 2000 FCRPS Biological Opinion (BiOp) included project, total in-river, and system survival estimates for Snake River salmonids outmigrants from 1994 through 1999. One purpose of the table was to support performance standards regarding juvenile in-river survival. Survival in the years 1994 through 1999 was used to establish a baseline (“pre BiOp”) condition; i.e., a base from which the actions called for in the BiOp were envisioned to improve juvenile survival in the hydropower system. It is generally agreed that empirical data should provide the basis for estimates and standards, rather than “pure” model output. However, the BiOp table necessarily included some estimates which were modeled (using SIMPAS), because empirical data were not available for some river reaches. In light of recent empirical information obtained in the years since the BiOp was finalized in 2000, we took a fresh look at the historical estimates that were used to establish baseline survival, and hence the hydro performance standards, in the BiOp.

Empirical data were unavailable for some reaches in some of the early years, so the BiOp relied on SIMPAS output, i.e., for survival below McNary Dam for spring/summer (sp/su) chinook salmon in 1994 through 1998 and in the same stretch for steelhead in 1994 through 1996. A direct comparison of SIMPAS output with empirical data for those years is not possible.

However, empirical data for survival through the FCRPS are available since 1999 for sp/su chinook salmon and since 1997 for steelhead. If we apply the SIMPAS model to recent years' data, and we assume that the relationship between SIMPAS output and empirical data is the same in recent years as it was in earlier years, then we have an indirect method to assess the accuracy of the SIMPAS output in years with no empirical data. For example, if we find that between 1999 and 2002 SIMPAS output exceeded empirical estimates for sp/su chinook salmon by certain amount, on average, then we might assume that the same average overestimate occurred between 1994 and 1998. By adjusting the estimates derived from SIMPAS in those years accordingly, we would presumably obtain a more accurate baseline survival from which to assess progress toward and compliance with performance standards (the standards themselves would likely need revision, as they were calculated as improvements from the baseline).

SNAKE RIVER SPRING/SUMMER CHINOOK SALMON

1994-1999 in-river survival estimates from BiOp

Portions of BiOp Table 6.2-7. dealing strictly with in-river survival of Snake River spring/summer chinook salmon (i.e., omitting information on transportation and delayed mortality) are reproduced in Table 1, with annotations added. The table gives estimated survival probabilities (percent survival) for passage through the eight hydroelectric projects encountered by juvenile salmonids migrating seaward from the Snake River basin. Each survival probability is identified by a three-letter abbreviation for the dam, and the quantity itself represents the combined survival probability for passage through the dam and the pool behind it. Estimates based on empirical data are unshaded; shaded cells represent SIMPAS output.

For most years (1994 is the exception, as noted below), survival estimates are calculated in three components: (1) LGR alone; (2) LGS, LMN, IHR, and MCN; and (3) JDA, TDA, and BON.

The empirical estimates for "LGR" in 1994, 1995, 1996, and 1998 are derived from survival estimates of PIT-tagged fish released from the Snake River smolt trap, which is located near the head of LGR pool. In each of those years, survival was estimated separately for hatchery and wild sp/su chinook salmon from the trap to the tailrace of LGR dam. The survival estimate in Table 1 is the average of the two survival estimates, weighted by the number of fish used to estimate survival for each group. For 1999, hatchery and wild fish PIT tagged at the trap were pooled, and a single survival estimate was calculated for the combined group. In 1997, river flow was too high to operate the trap during the bulk of the sp/su chinook salmon migration, so no PIT-tagged fish were released that year. SIMPAS was used to estimate LGR survival in that year (see below).

Empirical estimates for LGS and LMN in all years, and for IHR and MCN in all years except 1994, were estimated from PIT-tagged fish grouped daily at LGR according to their date of passage or tagging at LGR. Each daily group comprised all sp/su chinook salmon of hatchery or wild origin that were either (1) PIT tagged above LGR and were detected and returned to the tailrace at LGR, or (2) collected and tagged at the dam and released into the tailrace on the same day. Survival was estimated for each daily group (groups were sometimes pooled over two or more days to obtain sufficient sample sizes for estimation). The survival estimates in the table for LGS and LMN are the annual averages of the corresponding reach estimates for daily groups. The averages are weighted by the respective estimated relative variances of the daily survival estimates. Because PIT tags are not detected at IHR, it is not possible to estimate IHR and MCN survival separately. Instead, the weighted average was calculated for the combined survival for the two projects, and the square root of the average was entered as the empirical estimate in the table for both projects, because these reservoirs are approximately the same length.

The empirical estimates in 1999 for the JDA, TDA, and BON reaches were calculated in a similar way: hatchery and wild fish detected and returned to the river at MCN were combined in weekly groups according to passage date and survival was estimated for each group. The survival estimates in the table for JDA are the annual weighted averages of the corresponding reach estimates for weekly groups. Because PIT tags are not detected at TDA, it is not possible to estimate TDA and BON survival separately. Instead, the weighted average was calculated for the combined survival for the two projects, the SIMPAS-modeled dam survival was accounted for, and the remaining combined pool survival was apportioned to the two pools according to their respective lengths.

All other estimates for individual reaches in Table 1 were obtained from SIMPAS. The Pool+Dam estimates were obtained by first modeling dam survival for all eight dams, based on the particular flow and spill conditions, operations at each dam and using best available passage parameters. Empirical estimates from PIT-tagged fish are by nature estimates for pool+dam combined. Pool survival estimates for these reaches were obtained by dividing the PIT-tag estimate by the SIMPAS-modeled dam survival. An empirical estimate of per-pool-mile survival was then calculated from these pool survival estimates. Pool survival estimates for JDA, TDA, and BON (and LGR in 1997 and IHR and MCN in 1994) were calculated by applying the per-mile survival rate in the "empirical reaches" to their respective pool lengths.[6] Finally, the modeled dam survival and the pool estimates from per-mile extrapolation were combined to give the project (combined pool+dam) survival.

Table 1 includes columns to summarize the estimates for each of the three "components" (series of project survival estimates) and for all 8 projects, which estimates the complete in-river hydrosystem survival from the head of Lower Granite reservoir to the tailrace of Bonneville Dam. The 6-year mean survival from LGR to BON was estimated as 40.8 percent.

1999-2002 empirical estimates vs. SIMPAS output

Table 2 repeats the line for 1999 from Table 1, and extends that table with empirical survival estimates for 2000 through 2002. Empirical estimates for the combined reaches IHR+MCN and TDA+BON were partitioned to the individual reaches as described above.

Table 3 repeats the columns from Table 2 for JDA, TDA, and BON, and adds a column for the empirical estimate for the combined JDA-BON reach. The next four columns are the estimates from SIMPAS methods described above, applied to 1999 through 2002 conditions. The SIMPAS survival estimates for JDA-BON exceeded the empirical estimates for 1999 (SIMPAS was 5 percent greater), 2000 (15 percent), and 2001 (19 percent). The SIMPAS estimate was

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[6] In all that follows, when the phrases "SIMPAS estimate" or "SIMPAS survival" are used, the estimate is based on this per-mile extrapolation of pool survival.

only 91 percent of the empirical estimate in 2002 (preliminary, but "pretty close," estimate and SIMPAS run). For the 4 years, the geometric mean of the SIMPAS/empirical ratio was 1.0691. That is, on average, SIMPAS overestimated the empirical estimate by 6.9 percent from 1999 through 2002. Reach-by-reach, SIMPAS exceeded the empirical survival estimate by 1.7 percent for JDA, by 1.8 percent for TDA, and by 3.4 percent for BON.

Adjustments to original BiOp estimates

Table 4 repeats the estimates in Table 1, but the SIMPAS output for 1994-1998 has been adjusted according to the 1999-2002 SIMPAS vs. empirical analysis above. For example, it was assumed that the 1998 SIMPAS survival estimate of 63.4 percent for JDA-BON exceeded what would have been derived empirically by 6.91 percent. Thus, the 1998 estimated survival of 63.4 percent is adjusted downward to 59.3 percent, and the corresponding LGR-BON survival estimate is adjusted from 45.1 percent to 42.3 percent.

Overall, the 6-year mean survival from LGR to BON is adjusted from 40.8 percent to 38.7 percent.

(Table 4 incorporates one other, very minor, adjustment from the original BiOp estimates from Table 1. Namely, all the empirical estimates for LGR in Table 4 are for pooled hatchery and wild fish from the Snake River smolt trap, rather than weighted averages of separate estimates for hatchery and wild fish. This adjustment causes very small changes in the estimated survival. We have included this adjustment so that the estimates are consistent with our preferred approach of estimating survival after pooling groups if the separate estimates for the groups are not significantly different).

SNAKE RIVER STEELHEAD

1994-1999 in-river survival estimates from BiOp

Portions of BiOp Table 6.2-7. dealing strictly with in-river survival of Snake River steelhead are reproduced as Table 5 here, with annotations added. See the chinook salmon section for details regarding table structure and general methods. Where methods for steelhead differed from those for chinook salmon, it is noted in Table 5 and discussed below. As with chinook salmon, for steelhead in all years except 1994 survival estimates were calculated in three components: (1) LGR alone; (2) LGS, LMN, IHR, and MCN; and (3) JDA, TDA, and BON.

In 1994, estimates for wild and hatchery steelhead from the Snake River smolt trap to LGR tailrace were not reliable. SIMPAS estimates were used for that reach in1994. Unlike chinook salmon, sufficient steelhead were tagged at the trap in 1997 to obtain an empirical estimate.

With one exception, noted below, methods that led to the table values of steelhead survival for LGS, LMN, IHR, and MCN were identical to those for chinook salmon.

Steelhead detection at dams downstream from MCN were sufficient to estimate survival to BON tailrace in 1997, 1998, and 1999. In 1997, detections at JDA were not sufficient to estimate survival for specific reaches, but survival was estimated between MCN tailrace and BON tailrace. SIMPAS was used to estimated dam survival at JDA, TDA, and BON, and to apportion estimated total pool mortality to the three pools. Accordingly, the combined SIMPAS estimates for JDA, TDA, and BON match the empirical PIT-tag estimate between MCN tailrace and BON tailrace. In 1998 and 1999, separate empirical estimates were available for JDA and for the TDA and BON projects combined (i.e., JDA tailrace to BON tailrace). In 1999, SIMPAS was used to model dam survival at TDA and BON and to apportion estimated total pool mortality to the two pools. In 1998, a different method was used, as explained in the next paragraph.

There were three instances where empirical (PIT-tag) reach-specific survival estimates were available, but were not used directly in the BiOp analysis. In all three cases, empirical estimates were "overruled" because, along with the SIMPAS-modeled dam survival, they implied pool survival in excess of 100 percent. (PIT-tag estimates apply to one pool and one dam. Using SIMPAS, pool survival is estimated by dividing the PIT-tag reach survival estimate by a modeled value of survival for the dam alone. If the PIT-tag estimate exceeds the modeled dam passage survival, then the pool estimate exceeds 100 percent). Two of these instances occurred for LMN: the empirical estimates of 96.2 percent and 95.1 percent for 1995 and 1996, respectively, were reduced to 95.0 percent and 93.7 percent (the reduction represents one standard error), so that the pool estimate was below 100 percent.

The third instance was for TDA and BON in 1998. The empirical estimate for the combined two pools and dams was 93.5 percent, while the SIMPAS model of TDA and BON dam survival alone was only 85.3 percent. In this case, the survival number in Table 5 represents the SIMPAS-modeled dam survival and pool survival for TDA and BON calculated from estimated per-mile survival based on the empirical estimate of survival between MCN tailrace and BON tailrace. The resulting estimates were 89.7 percent for TDA and 91.8 percent for BON; the product of the two is 82.3 percent, considerably lower than the empirical estimate of 93.5 percent.

The consequence of "overruling" empirical data in cases where implied pool survival was greater than100 percent is that the numbers entered into Table 6.2-7 (Table 5 here) are less than the estimates from empirical data. The effect is particularly great in 1998, where the BiOp analysis gave LGR-BON survival of 41.8 percent (Table 5) and the empirical estimate is 47.4 percent (Table 6, and see below).

The 6-year mean survival from LGR to BON was estimated in the BiOp as 41.5 percent.

1999-2002 empirical estimates vs. SIMPAS output

Table 6 repeats the lines for 1997 through 1999 from Table 5 (reinstating the empirical estimates for TDA and BON for 1998), and extends that table with empirical estimates for 2000 through 2002.

Table 7 repeats the columns from Table 2 for JDA, TDA, and BON, and adds a column for the empirical estimate for the combined JDA-BON reach. The next four columns are the output from SIMPAS methods described above applied to 1997 through 2002 conditions. The SIMPAS survival for JDA-BON exceeded the empirical estimate in 3 years and was less than the empirical estimate in 3 years. The geometric mean of the SIMPAS/empirical ratios for the 6 years was 0.962 (i.e., SIMPAS underestimated empirical survival for steelhead). Reach-by-reach, SIMPAS overestimated the empirical by 3.0 percent for JDA, underestimated by 2.4 percent for TDA, and underestimated by 4.4 percent for BON.

Adjustments to original BiOp estimates
Table 8 repeats the estimates in Table 5 (restoring empirical estimates for LMN in 1995 and 1996 and TDA+BON in 1998), but the SIMPAS output for 1995 through 1997 has been adjusted according to the 1997-2002 SIMPAS vs. empirical analysis above. For example, it was assumed that the 1994 SIMPAS survival of 47.5 percent for JDA-BON was 96.2 percent of what would have been derived empirically. Thus, 47.5 percent was adjusted upward to 49.4 percent. The corresponding LGR-BON survival estimate is adjusted from 32.2 percent to 33.5 percent.

Overall, the 6-year mean survival from LGR to BON is adjusted upward from 41.5 percent to 43.7 percent.

(Note the other difference between Tables 5 and 8: all empirical estimates for LGR in Table 8 are for pooled hatchery and wild fish from the Snake River smolt trap, rather than weighted averages of separate estimates for hatchery and wild fish. See sp/su chinook salmon section for discussion.)

DISCUSSION
The adjusted survival estimates in this document are based on a set of adjustment factors estimated from comparisons of recent empirical and SIMPAS estimates. The adjustment factors are estimates themselves, calculated from 4 years of data for sp/su chinook salmon and from 6 years of data for steelhead. In each future year in which it is possible to derive empirical estimates from the head of LGR pool to BON tailrace, it will be possible to apply these methods to gain one more "data point" for estimation of adjustment factors, and we presume that the estimated adjustment factor will become more accurate and precise as more data are added. We recommend that the estimated average pre-BiOp survival, and the hydrosystem survival performance standards based on the estimated pre-BiOp average should be updated at each of the 3-, 5-, 8-year check-ins, and before conducting the final 10-year compliance test (estimated adjustment factors will not change appreciably between 8- and 10-year tests).

Table 1. Project and system survival for Snake River spring/summer chinook salmon 1994-1999, excerpted from Table 6.2-7 of 2000 FCRPS Biological Opinion, December 21, 2000. Unshaded cells represent empirical estimates from PIT-tag data. Shaded cells were calculated using SIMPAS: modeled dam survival and reservoir survival extrapolated from estimated per-mile reservoir survival extrapolated from reaches with empirical estimates.

	Project survival (% Pool + Dam Survival)								**Components of Complete In-river Survival**			**Percent In-river Survival (LGR to BON)**
Year	**LGR**	**LGS[a]**	**LMN[a]**	**IHR[ab]**	**MCN[ab]**	**JDA**	**TDA**	**BON**	**LGR**	**LGS-MCN**	**JDA-BON**	
1994	93.6[c]	83.0	84.7	89.0	85.8	77.3	84.5	82.9	93.6	70.3[d]	41.3[e]	27.2
1995	90.6[c]	88.2	92.5	93.6	93.6	85.2	87.2	86.9	90.6	71.5	64.6	41.8
1996	97.9[c]	92.6	92.9	87.0	87.0	84.4	86.9	87.0	97.9	65.1	63.8	40.6
1997	91.3	94.2	89.4	89.3	89.3	83.3	86.5	86.9	91.3	67.2	62.6	38.4
1998	92.4[c]	98.5	85.3	95.7	95.7	82.2	87.7	88.0	92.4	77.0	63.4	45.1
1999	94.1[f]	95.0	92.5	95.1	95.1	85.3[g]	89.3[gh]	91.1[gh]	94.1	79.5	69.4	51.9
6-yr avg	93.3	91.9	89.5	91.6	91.1	82.9	87.0	87.2	93.3	71.7	63.0	40.8

a. Empirical estimates based on pooled hatchery and wild fish grouped at LGR: average of estimates for daily groups weighted by relative variance.

b. When empirical (unshaded): square root of empirical estimate between LMN tailrace and MCN tailrace.

c. Average of hatchery and wild fish tagged at and released from Snake River smolt trap, weighted by respective number tagged.

d. LGS-LMN for 1994.

e. IHR-BON for 1994.

f. Pooled hatchery and wild fish tagged at and released from Snake River smolt trap.

g. Empirical estimates based on pooled hatchery and wild fish grouped at MCN: average of estimates for weekly groups weighted by relative variance.

h. Calculated from empirical estimate between JDA tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

Table 2. Empirical estimates of project and system survival for Snake River spring/summer chinook salmon, 1999-2002, based on PIT-tag data.

	Project survival (% Pool + Dam Survival)								**% In-river Survival (LGR to BON)**
YEAR	**LGR**[a]	**LGS**[b]	**LMN**[b]	**IHR**[bc]	**MCN**[bc]	**JDA**[d]	**TDA**[de]	**BON**[de]	
1999	94.1	94.9	92.5	95.1	95.1	85.3	89.3	91.1	51.8
2000	92.2	93.8	88.7	96.3	96.3	89.8	83.9	81.5	43.7
2001	95.6	93.9	82.0	84.9	84.9	75.8	81.4	79.3	25.9
2002	95.3	90.1	97.4	90.9	90.9	90.7	90.1	93.2	52.6

a. Pooled hatchery and wild fish tagged at and released from Snake River smolt trap.

b. Empirical estimates based on pooled hatchery and wild fish grouped at LGR: average of estimates for daily groups weighted by relative variance.

c. Square root of empirical estimate between LMN tailrace and MCN tailrace.

d. Empirical estimates based on pooled hatchery and wild fish grouped at MCN: average of estimates for weekly groups weighted by relative variance.

e. Calculated from empirical estimate between JDA tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

Table 3. Empirical estimates of survival for Snake River spring/summer chinook salmon in lower river compared to results of SIMPAS model based on survival to McNary Dam (method used in 1995-1998).

YEAR	Empirical estimates				SIMPAS Method				Ratio SIMPAS/Empirical			
	JDA	TDA	BON	JDA-BON	JDA	TDA	BON	JDA-BON	JDA	TDA	BON	JDA-BON
1999	85.3	89.3	91.1	69.4	90.8	88.9	90.4	73.0	1.0645	0.9955	0.9923	1.0512
2000	89.8	83.9	81.5	61.4	88.5	88.6	90.3	70.8	0.9855	1.0560	1.1080	1.1533
2001	75.8	81.4	79.3	48.9	80.1	84.8	85.6	58.1	1.0567	1.0418	1.0794	1.1887
2002	90.7	90.1	93.2	76.2	87.4	88.2	89.6	69.1	0.9636	0.9789	0.9614	0.9065
Geometric Mean									**1.0166**	**1.0176**	**1.0335**	**1.0691**

Table 4. Project and system survival for Snake River spring/summer chinook salmon 1994-1999, derived from Table 6.2-7 of 2000 FCRPS Biological Opinion, December 21, 2000 (see Table 1), and adjustments based on comparison of recent empirical estimates and SIMPAS model results (see Table 3). Unshaded cells represent empirical estimates from PIT-tag data. Shaded cells are based on adjusted SIMPAS results.

Year	Project survival (% Pool + Dam Survival)								Components of Complete In-river Survival			% In-river Survival (LGR to BON)
	LGR	LGS[a]	LMN[a]	IHR[ab]	MCN[ab]	JDA	TDA	BON	LGR	LGS-MCN	JDA-BON	
1994	93.0[c]	83.0	84.7	89.0	85.8	76.0	83.0	80.2	93.0	70.3[d]	38.7[e]	25.3
1995	90.5[c]	88.2	92.5	93.6	93.6	83.8	85.7	84.1	90.5	71.5	60.4	39.1
1996	97.8[c]	92.6	92.9	87.0	87.0	83.0	85.4	84.2	97.8	65.1	59.7	38.0
1997	91.3	94.2	89.4	89.3	89.3	81.9	85.0	84.1	91.3	67.2	58.6	35.9
1998	92.6[c]	98.5	85.3	95.7	95.7	80.9	86.2	85.1	92.6	77.0	59.3	42.3
1999	94.2[c]	95.0	92.5	95.1	95.1	85.3[f]	89.3[fg]	91.1[fg]	94.2	79.5	69.4	51.9
6-yr avg	93.2	91.9	89.5	91.6	91.1	81.8	85.8	84.8	93.2	71.7	59.7	38.7

a. Empirical estimates based on pooled hatchery and wild fish grouped at LGR: average of estimates for daily groups weighted by relative variance.

b. When empirical (unshaded): square root of empirical estimate between LMN tailrace and MCN tailrace.

c. Pooled hatchery and wild fish tagged at and released from Snake River smolt trap.

d. LGS-LMN for 1994.

e. IHR-BON for 1994.

f. Empirical estimates based on pooled hatchery and wild fish grouped at MCN: average of estimates for weekly groups weighted by relative variance.

g. Calculated from empirical estimate between JDA tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

Table 5. Project and system survival for Snake River steelhead 1994-1999, excerpted from Table 6.2-7 of 2000 FCRPS Biological Opinion, December 21, 2000. Unshaded cells represent empirical estimates from PIT-tag data. Shaded cells were calculated using SIMPAS: modeled dam survival and reservoir survival extrapolated from estimated per-mile reservoir survival extrapolated from reaches with empirical estimates.

Year	Project survival (% Pool + Dam Survival)								Components of Complete In-river Survival			% In-river Survival (LGR to BON)
	LGR	LGS[a]	LMN[a]	IHR[ab]	MCN[ab]	JDA[c]	TDA[c]	BON[c]	LGR	LGS-MCN	JDA-BON	
1994	90.0	84.4	89.2	90.8	88.2	81.3	85.8	85.0	90.0	75.3[d]	47.5[e]	32.2
1995	94.4[f]	89.9	95.0[g]	92.7	92.6	88.4	88.1	88.7	94.4	73.3	69.1	47.8
1996	93.4[f]	93.8	93.7[g]	88.9	88.9	86.0	87.3	87.8	93.4	69.5	65.9	42.8
1997	96.3[f]	96.6	90.2	91.3	91.4	85.1[h]	87.0[h]	88.0[h]	96.3	72.7	65.2	45.5
1998	92.5[f]	93.0	88.9	89.3	89.3	83.1	89.7[hi]	91.8[hi]	92.5	65.9	68.4[j]	41.8
1999	90.8[k]	92.6	91.5	91.3	91.3	92.0	84.0[l]	81.2[l]	90.8	70.6	62.8	40.2
6-yr avg	92.9	91.7	91.4	90.7	90.3	85.8	87.0	86.9	92.9	71.2	65.1	41.5

a. Empirical estimates based on pooled hatchery and wild fish grouped at LGR: average of estimates for daily groups weighted by relative variance.

b. When empirical (unshaded): square root of empirical estimate between LMN tailrace and MCN tailrace.

c. When empirical (unshaded): based on pooled hatchery and wild fish grouped at MCN: average of estimates for weekly groups weighted by relative variance.

d. LGS-LMN for 1994.

e. IHR-BON for 1994.

f. Average of hatchery and wild fish tagged at and released from Snake River smolt trap, weighted by respective number tagged.

g. For BiOp, empirical estimates were decreased by one standard error to avoid estimates of pool survival in excess of 100 percent.

h. Calculated from empirical estimate between MCN tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

i. Empirical estimate between JDA tailrace and BON tailrace not used to avoid pool survival estimates in excess of 100 percent.

j. Product of JDA, TDA, and BON numbers. While the JDA number is the PIT-tag estimate between MCN tailrace and JDA tailrace, the others are calculated

from estimate between MCN tailrace and BON tailrace. The consequence is that the overall JDA-BON empirical estimate was underestimated.

k. Pooled hatchery and wild fish tagged at and released from Snake River smolt trap.

l. Calculated from empirical estimate between JDA tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

Table 6. Empirical estimates of project and system survival for Snake River steelhead, 1997-2002, based on PIT-tag data.

YEAR	Project survival (% Pool + Dam Survival)								% In-river Survival (LGR to BON)
	LGR[a]	LGS[b]	LMN[b]	IHR[bc]	MCN[bc]	JDA[d]	TDA[de]	BON[de]	
1997	96.4	96.6	90.2	91.3	91.4	85.1	87.0	88.0	45.6
1998	92.4	93.0	88.9	89.3	89.3	83.1	93.7	99.8	47.4
1999	90.8	92.6	91.5	91.3	91.3	92.0	84.0	81.2	40.2
2000	95.4	90.1	90.4	91.8	91.8	85.1	88.1	85.6	42.0
2001	91.3	80.1	70.9	54.4	54.4	33.7	87.6	86.0	3.9
2002	89.8	90.3	91.2	80.6	80.6	84.4	80.7	75.8	24.8

a. Pooled hatchery and wild fish tagged at and released from Snake River smolt trap.

b. Empirical estimates based on pooled hatchery and wild fish grouped at LGR: average of estimates for daily groups weighted by relative variance.

c. Square root of empirical estimate between LMN tailrace and MCN tailrace.

d. Empirical estimates based on pooled hatchery and wild fish grouped at MCN: average of estimates for weekly groups weighted by relative variance.

e. Calculated from empirical estimate between JDA tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

Table 7. Empirical estimates of survival for Snake River steelhead in lower river compared to results of SIMPAS model based on survival to McNary Dam (method used in 1995-1996).

	Empirical estimates				**SIMPAS Method**				**Ratio SIMPAS/Empirical**			
YEAR	**JDA**	**TDA**	**BON**	**JDA-BON**	**JDA**	**TDA**	**BON**	**JDA-BON**	**JDA**	**TDA**	**BON**	**JDA-BON**
1997	85.1	87.0	88.0	65.1	89.0	88.2	90.3	70.9	1.0456	1.0142	1.0267	1.0887
1998	83.1	93.7	99.8	77.7	83.7	86.5	85.9	62.2	1.0071	0.9234	0.8614	0.8010
1999	92.0	84.0	81.2	62.7	85.6	87.2	87.0	64.9	0.9300	1.0376	1.0715	1.0340
2000	85.1	88.1	85.6	64.2	85.9	89.7	88.5	68.2	1.0097	1.0180	1.0339	1.0627
2001	33.7	87.6	86.0	25.4	46.3	73.8	62.4	21.3	1.3729	0.8428	0.7262	0.8403
2002	84.4	80.7	75.8	51.7	74.4	83.9	81.4	50.8	0.8811	1.0390	1.0742	0.9835
Geometric Mean									**1.0303**	**0.9763**	**0.9562**	**0.9619**

Table 8. Project and system survival for Snake River steelhead 1994-1999, derived from Table 6.2-7 of 2000 FCRPS Biological Opinion, December 21, 2000 (see Table 1), and adjustments based on comparison of recent empirical estimates and SIMPAS model results (see Table 3). Unshaded cells represent empirical estimates from PIT-tag data. Shaded cells are based on adjusted SIMPAS results.

Year	Project survival (% Pool + Dam Survival)								Components of Complete In-river Survival			% In-river Survival (LGR to BON)
	LGR	LGS[a]	LMN[a]	IHR[ab]	MCN[ab]	JDA[c]	TDA[c]	BON[c]	LGR	LGS-MCN	JDA-BON	
1994	90.0	84.4	89.2	90.8	88.2	78.9	87.9	88.9	90.0	75.3[d]	49.4[e]	33.5
1995	94.4[f]	89.9	96.2	92.7	92.6	85.8	90.2	92.8	94.4	74.2	71.8	50.3
1996	93.4[f]	93.8	95.1	88.9	88.9	83.5	89.4	91.8	93.4	70.5	68.5	45.1
1997	96.3[f]	96.6	90.2	91.3	91.4	85.1[g]	87.0[g]	88.0[g]	96.3	72.7	65.2	45.6
1998	92.5[f]	93.0	88.9	89.3	89.3	83.1	93.7[h]	99.8[h]	92.5	65.9	77.7	47.4
1999	90.8[f]	92.6	91.5	91.3	91.3	92.0	84.0[h]	81.2[h]	90.8	70.6	62.8	40.2
6-yr avg	92.9	91.7	91.4	90.7	90.3	84.7	88.7	90.4	92.9	71.2	65.1	43.7

a. Empirical estimates based on pooled hatchery and wild fish grouped at LGR: average of estimates for daily groups weighted by relative variance.

b. When empirical (unshaded): square root of empirical estimate between LMN tailrace and MCN tailrace.

c. When empirical (unshaded): based on pooled hatchery and wild fish grouped at MCN: average of estimates for weekly groups weighted by relative variance.

d. LGS-LMN for 1994.

e. IHR-BON for 1994.

f. Pooled hatchery and wild fish tagged at and released from Snake River smolt trap.

g. Calculated from empirical estimate between MCN tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

h. Calculated from empirical estimate between MCN tailrace and BON tailrace, based on per-mile reservoir survival and SIMPAS-modeled dam survival.

Attachment 2 – Smith & Zabel

Steve Smith and Rich Zabel December 17, 2002

Estimating survival of Snake River fall chinook salmon through the hydrosystem

Overview

Estimating survival of Snake River fall chinook salmon through the hydrosystem has been problematic. Because survival of these fish is relatively poor, we are only able to reliably estimate survival to Lower Monumental Dam. With proposed increased sample sizes in 2003, though, we will have the potential to extend the range of our estimates. Below we discuss the details of these increased sample sizes and the precision in survival estimates we expect to observe in migration year 2003 and beyond.

Extrapolating survival through the entire hydrosystem also presents problems. It is clear that the behavior of Snake River fall chinook changes substantially as the fish progress downstream. Here we propose a method to extrapolates survival to downstream reaches that incorporates the change in behavior.

Finally, survival estimates for fall chinook are based primarily on hatchery fish. We briefly discuss protocols for comparing hatchery to wild fish to justify using fish as surrogates for wild fish.

Survival estimates for Snake River subyearling fall chinook salmon downstream from Lower Granite Dam

Valid survival estimates for subyearling fall chinook salmon cannot be obtained by taking PIT-tagged fish directly from Lyons Ferry Hatchery and releasing them in the tailrace of Lower Granite Dam (LGR). Such fish would not have the necessary period of rearing in the river before initiating migration and arriving at LGR. Thus, survival estimation downstream from LGR must rely on PIT-tagged fish released upstream from the dam. The approach is to track detections at LGR of subyearlings from all upstream release sites, to group them according to detection date, and to treat weekly groupings as separate "release groups" (fish returned to the tailrace rather than transported from LGR) for estimation of subsequent survival using the Cormack-Jolly-Seber (CJS) model.

Lyons Ferry fish have been PIT-tagged and trucked to release sites upstream from LGR every year since 1995. Sample sizes have been set primarily for estimation of survival to LGR, and the studies have provided considerable amounts of useful information. However, the numbers of fish detected at LGR and returned have been relatively small, and we have been able to obtain precise annual survival estimates only to Lower Monumental Dam (LMO). For only a few weekly groups over the 8 years have there been sufficient detections at McNary Dam (MCN) and downstream (John Day Dam [JDA], Bonneville Dam [BON], estuary PIT-trawl) to estimate survival to MCN. Reliable estimates below McNary have not been obtained for any weekly group.

Most of the reliable estimates from LGR to MCN were for weekly groups in 1998. In that year a total of 20,330 PIT-tagged subyearling chinook salmon were detected and returned to the river at LGR. Reasonably precise estimates were obtained for the following weekly groups from LGR:

Dates	Number	LGR-LMO Survival (std. err.)
Jun 22-29	355	0.512 (0.094)
Jun 30 – Jul 6	510	0.579 (0.104)
Jul 7-13	5,292	0.580 (0.032)
Jul 14-20	6,073	0.550 (0.024)
Jul 21-27	2,334	0.439 (0.028)
Jul 28-Aug 4	1,422	0.506 (0.034)
Aug 5-11	1,304	0.529 (0.041)
Aug 12-18	1,166	0.418 (0.045)
Aug 19-25	370	0.182 (0.033)
Aug 26-Sep 1	213	0.028 (0.015)

The number of PIT-tagged fish detected and returned to the river at LGR has been much lower in most other years: 2,680 in 1995; 4,397 in 1996; 15,891 in 1997; 6,123 in 1999; 3,397 in 2000; 11,449 in 2001.

In 2002, NMFS began a multi-year study of transportation of subyearling fall chinook salmon from LGR. In the first year of the study almost 100,000 PIT-tagged Lyons Ferry fish were released about 40 km from the confluence of the Snake and Clearwater Rivers. These fish were released in late May and early June, roughly corresponding in time to the earliest releases at Pittsburg Landing and Billy Creek for the NMFS subyearling survival study. Survival estimation using these fish was not very successful, however. Fish condition was poor, leading to high mortality upstream from LGR, and 80 percent of all detected fish at LGR, LGO, and LMO were transported. Only about 3,000 of these fish were detected and returned to the river at LGR; fewer than 300 were detected downstream from MCN.

The transportation study will continue in 2003 and beyond, for a minimum of three more years, and as many as six or more additional years. Prospects for survival estimation downstream from LGR are quite good in these years, as: (1) hatchery conditions that led to poor fish health in 2002 have been addressed; (2) release numbers have been increased to 150,000; and (3) a total of 20,000 detected fish will be returned to the river at LGR.

To determine the expected precision of survival estimates resulting from these 20,000 fish, we assumed that per-project survival probability was 0.8, detection probabilities were 0.45 at LGR, LGO, LMO, and MCN. Detection probability of 0.15 was assumed at JDA, and the probability that a PIT-tagged fish alive below JDA would survive to and be detected at some downstream site was assumed 0.10. Unintentional transportation of detected fish was set at 10 percent at all transport dams. A distribution through time of the 20,000 fish leaving LGR was assumed, based on annual passage distributions of fish from early release groups from the survival study. (All these assumed numbers were derived from results of the survival study.)

The expected precision (half-width of 95 percent confidence interval) of the mean survival estimate through each reach is indicated in the following table:

Reach	Expected precision of mean estimate
LGR-LGO	0.030
LGO-LMO	0.036
LMO-MCN	0.057
MCN-JDA	0.148
LGR-JDA	0.048

Extrapolating survival estimates

The two commonly-employed methods for extrapolating survival estimates from upstream reaches to downstream reaches are per-project or per-km extrapolations. Both of these methods assume that behavior among reaches is fairly uniform. This is not the case for Snake River fall chinook. A pattern that is consistent from year-to-year is that migration rate increases significantly as fish progress downstream (Fig. 1). This is probably because fish undergo less rearing as they move downstream.

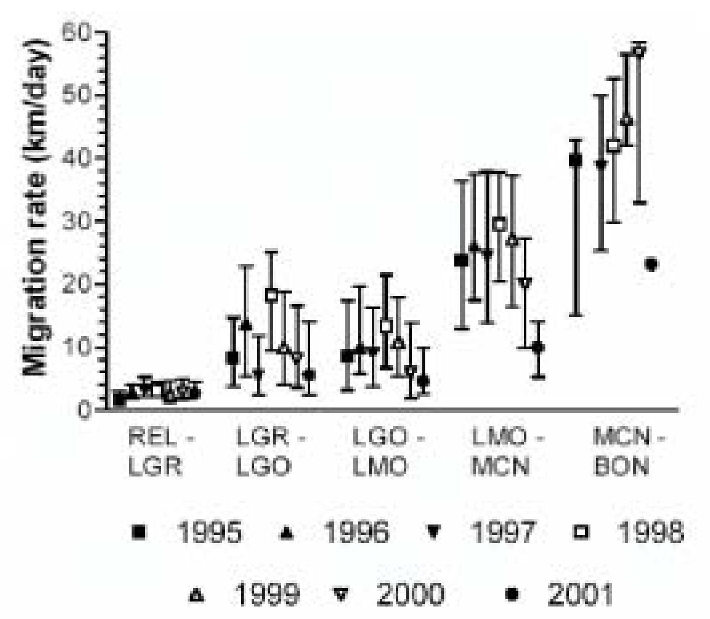

Figure 1. Median migration rates (with 20th and 80th percentiles) of Snake River fall chinook salmon by reach and year. From Smith et al. (2002).

Snake River fall chinook suffer considerable reservoir mortality (likely due to predation), and we expect that the level of mortality is related to exposure time. Since fish spend much less time in lower reservoirs than in upper ones, we would expect lower mortality in lower reservoirs. A method that incorporates these expectations is to extrapolate reservoir mortality based on residence time after accounting for dam mortality. Although sample sizes in lower reaches are currently not large enough to estimate survival, they do provide information on residence times.

Methods

First, partition project survival (*Sp*) into dam survival (*Sd*) and reservoir survival (*Sr*):

$$Sp = Sd \cdot Sr \, .$$

Next we assume that reservoir survival is related to residence time, T:

$$Sr = (S\ daily)^{T} \approx \exp(-r \cdot T) \, .$$

Sdaily is the daily survival rate, and raising this to the Tth power yields estimated survival through *T* days. The continuous-time analog to this is an exponential function with survival rate r. Since our residence time data are continuous, we used the exponential form.

To fit this equation to survival and residence time data, first take logs:

$$Log(Sp) = log(Sd) - r \cdot T \, .$$

This equation can be fit using standard linear regression. We can either specify dam survival (using SIMPASS, for example) or we can fit it as the intercept of the regression. The equation can be elaborated by incorporating year, site, or temperature effects, if we so desire.

Results and Discussion

As a demonstration, we applied the above equation to weekly survival estimates and median residence times through the Lower Granite to Little Goose and Little Goose to Lower Monumental reaches for 1995 to 2001 (Fig. 2). We assumed a dam survival of 0.93. While the fit was highly significant ($P = 0.009$), the predictive power was relatively poor ($R^2 = 0.05$). However, because the survival estimates are highly variable, any predictive model will perform relatively poorly. We do believe, though, that the model captures the general trend in the data and will provide more realistic extrapolations of survival through the lower reaches. Also, including the factors mentioned above might improve model fit. To extrapolate to lower reaches, we simply apply the fitted relationship to observed residence times.

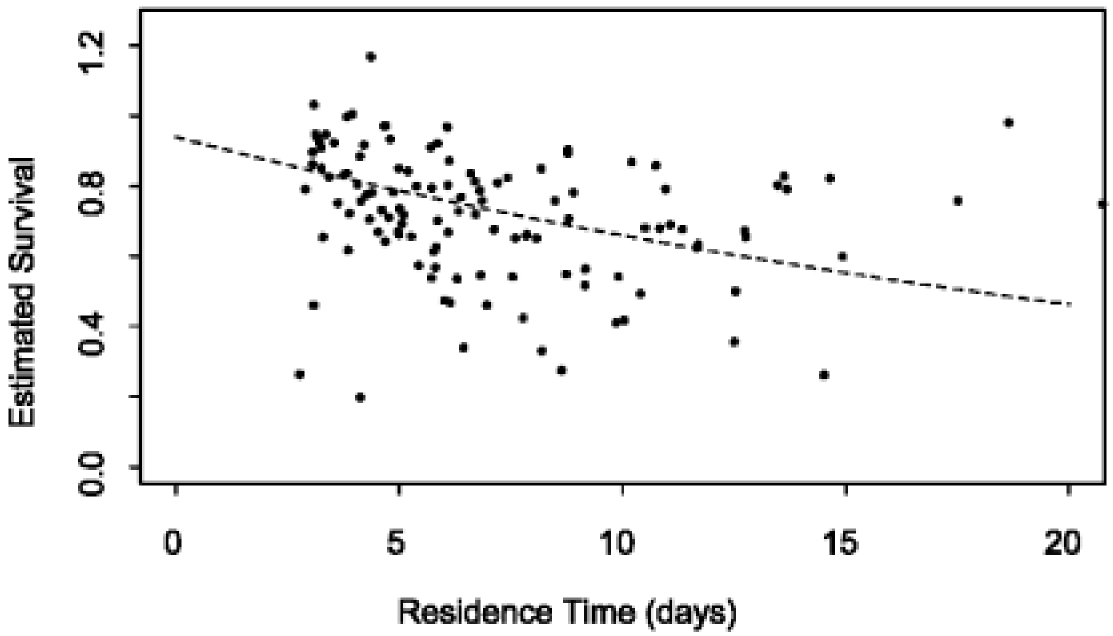

Figure 2. Regression of project survival versus residence time through the Lower Granite to Little Goose and Little Goose to Lower Monumental reaches for 1995-2001. Dam survival was set 0.93.

Comparing hatchery fish to wild fish

As mentioned above, estimating survival of Snake River fall chinook salmon through the hydrosytem relies on using hatchery fish as surrogates for wild fish. Capturing and tagging enough wild fish to generate reliable survival estimates through the hydrosytem is not practical. However, enough fish are tagged to estimate survival through some reaches and travel times through more. Thus we suggest, as part of the RME process, that the group undertakes a comparison of survival and travel time for comparable release groups of wild and hatchery fish through as many reaches as possible. This would be essentially an extension of the analysis conducted by Smith et al. (2002). As part of this effort, we should assess the feasibility of estimating survival of wild fish through the Lower Granite to Little Goose reach. An important consideration is that size may play an important role in both survival and travel time. Thus we may need to ensure that release groups of hatchery fish are selected so they have a size distribution equivalent to wild fish.

Reference

Smith et al. 2002. Fall chinook survival report. Available at www.bpa.gov.

Attachment 3 – Skalski, Lady & Smith

Draft

Decision Rules for Progress and Compliance Testing

For Smolt Passage Survival

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16 December 2002

Table of Contents

Introduction

The Biological Opinion (BiOp) has established performance standards for in-river survival of outmigrating salmonid smolts. The stated goals for increases in the in-river survival are to achieved on or before the year 2010. In assessing the success of mitigation actions aimed at improving in-river smolt survival, comparisons of pre-2000 and post-2000 survival estimates will be performed. Comparisons performed in 2005 and 2006 will be used to assess interim progress in achieving recovery goals. The comparisons performed in 2010 will be used to assess compliance with the BiOp performance standards.

Greater statistical certainty will need to be ascribed to the discussions concerning compliance versus the less formal statutory requirements needed for asserting progress. There will also be more information available at the time of the 2010 review than will be available in either 2005 or 2008. For these reasons, separate decision rules will be needed in assessing progress versus compliance.

In the following sections, the rationale and choice of decision rules proposed for progress and compliance testing will be presented. The anticipated performance of these decision rules will also be presented under non-recovery and recovery scenarios.

Compliance Rules

Initial Approach Using Standard Statistical Methods

Decision Rules

Statistical compliance testing in the year 2010 was initially conceptualized as applying standard statistical tests to one or more null hypotheses. Statistical tests performed at some α -level would be used to draw conclusions concerning possible compliance with stated performance standards. However, there is no unique set of hypotheses that adequately identifies the state of compliance or recovery. Instead, alternative testing procedures were evaluated. Ideally, a good test of compliance would have a low probability of concluding compliance if it had not occurred and a high probability of concluding compliance if it needed occurs. Therefore, the statistical performance of tests was evaluated by how close the statistical tests were to a nominal α -level when no recovery occurred and their power to conclude compliance when compliance was indeed true (i.e., $1-\beta$). Six alternative tests of compliance were initially compared; these were as follows:

Rule #1

Joint decision rule using

Test 1 $\quad \mathrm{H_{o1}}: \mu_{\mathrm{Post}} - \mu_{\mathrm{Pre}} \le 0$

$\qquad\quad \mathrm{H_{a1}}: \mu_{\mathrm{Post}} - \mu_{\mathrm{Pre}} > 0$

and

Test 2 $\quad \mathrm{H_{o2}}: \mu_{\mathrm{Post}} - \mu_{\mathrm{Pre}} \ge \Delta$

$\qquad\quad \mathrm{H_{a2}}: \mu_{\mathrm{Post}} - \mu_{\mathrm{Pre}} < \Delta$

Compliance would be concluded if H_{o1} is rejected and H_{02} is not rejected, each at a significance level of α. The value Δ is the required improvement in survival between pre- and post-2000 periods specified in the BiOp.

Rule #2
Simple decision rule using

$$\text{Test 1} \quad H_o: \mu_{Post} - \mu_{Pre} \le 0$$
$$H_a: \mu_{Post} - \mu_{Pre} > 0$$

Compliance would be concluded if H_o is rejected at a significance level of α.

Rule #3
Simple decision rule using

$$\text{Test 1} \quad H_o: \mu_{Post} - \mu_{Pre} \le \Delta$$
$$H_a: \mu_{Post} - \mu_{Pre} > \Delta$$

Compliance would be concluded if H_o is rejected at a significance level of α.

Rule #4
Joint decision rule using straight-line regression of survival versus year during the post-2000 period.

$$\text{Test 1} \quad H_{o1}: \alpha + \beta(2010) - \mu_{Pre} \le 0$$
$$H_{a1}: \alpha + \beta(2010) - \mu_{Pre} > 0$$

and

$$\text{Test 2} \quad H_{o2}: \alpha + \beta(2010) - \mu_{Pre} \ge \Delta$$
$$H_{a2}: \alpha + \beta(2010) - \mu_{Pre} < \Delta$$

Compliance would be concluded if H_{o1} is rejected and H_{02} is not rejected, each at a significance level of α.

Rule #5
Simple decision rule using

$$\text{Test 1} \quad H_o: \alpha + \beta(2010) - \mu_{Pre} \le 0$$
$$H_a: \alpha + \beta(2010) - \mu_{Pre} > 0$$

Compliance would be concluded if H_o is rejected at a significance level of α.

Rule #6
Simple decision rule using the asymptote (γ) of a hyperbolic function fit to the post-2000 data. The test would be based on the hypotheses

$$\text{Test 1} \quad H_o: \ \gamma - \mu_{Pre} \leq \Delta$$
$$H_a: \ \gamma - \mu_{Pre} > \Delta$$

Compliance would be concluded if H_o is rejected at a significance level of α.

Monte Carlo Results
Table 1 presents results of Monte Carlo simulations to estimate the observed α-level and statistical power $(1-\beta)$ of the various compliance tests. All tests were performed at α = 0.05. A null case of no recovery was simulated where pre- and post-2000 survival estimates had the

Table 1. Estimated probabilities of concluding compliance for a yearling chinook salmon smolt survival improvement of Δ = 0.09 from Lower Granite to Bonneville Dam at α = 0.05. Simulations were conducted under no improvement (i.e., $\Delta = 0$) and prescribed improvement (i.e., Δ) from 1 to 10 years after the year 2000. Decision Rules 1 through 6 were evaluated.

		Probabilities of Concluding Compliance						
Scenario		**Rule 1**	**Rule 2**	**Rule 3**	**Rule 4**	**Rule 5**	**Rule 6**	**Expectation**
No improvement		0.0025	0.000	0.000	0.306	0.000	0.000	α = 0.05
Recovery by year of size Δ	2010	0.200	0.200	0.000	0.481	0.028	0.010	1-B increasing
	2009	0.220	0.220	0.000	0.514	0.038	0.018	
	2008	0.268	0.268	0.000	0.593	0.055	0.033	
	2007	0.331	0.331	0.000	0.567	0.052	0.031	↓
	2006	0.387	0.387	0.000	0.569	0.062	0.036	
	2005	0.434	0.434	0.000	0.566	0.059	0.036	
	2004	0.504	0.504	0.000	0.566	0.048	0.045	
	2003	0.601	0.601	0.000	0.540	0.051	0.044	
	2002	0.665	0.665	0.000	0.481	0.043	0.035	
	2001	0.738	0.738	0.000	0.478	0.034	0.023	

Same mean and variance. This scenario corresponds to the situation where the tests shall reject the hypotheses of no recovery at α = 0.05. Few of the tests had observed α -levels near the nominal level tested. For Rule #2, the results under no recovery reflect the fact the two-sample t-test is not nominally distributed when the pre-2000 data are treated as fixed values. For Rules 1, 3, 4, 5, and 6, the no-recovery state of nature (i.e., $\mu_{\text{Post}} = \mu_{\text{Pre}}$) does not produce a centrally distributed test situation. Instead, the no-recovery state of nature is in the tail of the acceptance zone of the null hypotheses. As such, observed α -levels are far below the nominal value of α = 0.05.

Under full recovery, Monte Carlo simulations were performed where the expected survivals equaled target BiOp values 1, 2, …, 10 years after 2000. Immediate recovery in year 1 (i.e., 2001) is the most favorable condition, with typically the highest statistical power for concluding recovery (Table 1). A recovery trajectory that achieved its target goal only in year 10 (i.e., 2010) would typically have the lowest statistical power for concluding compliance (Table 1). Comparison of the performances for Rules 1 and 2 indicate the first rule is largely governed by the first set of hypotheses, i.e.,

$$\begin{aligned} \text{H}_{\text{o1}}:&\ \ \mu_{\text{Post}} - \mu_{\text{Pre}} \le 0 \\ \text{H}_{\text{a1}}:&\ \ \mu_{\text{Post}} - \mu_{\text{Pre}} > 0. \end{aligned}$$

Hence, the test of recovery in Rule #1 is not comparing post-2000 survivals to a standard of $\mu_{\text{Pre}} + \Delta$ but only to the pre-2000 mean (i.e., μ_{Pre}). Rule #3 had no chance of concluding recovery (i.e., H_{a}) even when smolt survivals equaled the target goal in expectation. The reason, to reject

$$\text{H}_{\text{o}}:\ \ \mu_{\text{Post}} - \mu_{\text{Pre}} \le \Delta$$

the observed mean for μ_{Post} needs to exceed $\mu_{\text{Pre}} + \Delta$ by an amount $t\sqrt{s^2\left(\frac{1}{6}+\frac{1}{10}\right)}$ to be statistically significant. If the post-2000 survivals at best have an expectation of only $\mu_{\text{Pre}} + \Delta$, it is unlikely the null hypothesis will be rejected in favor of concluding compliance.

Rules 5 and 6 have a similar difficulty. Under recovery of size Δ, the expected values of the linear [i.e., $\alpha + \beta(2010)$] and nonlinear regression (i.e., γ) projections are equal to $\mu_{\text{Pre}} + \Delta$. However, to reject H_{o} and conclude compliance, the projections need to be appreciably above the recovery target to be declared significant. This situation, however, occurs rarely under Rules 5 and 6. Behavior of Rule #2 is analogously affected, resulting in a maximum power of only 50 percent (Table 1).

From the behavior of the above rules, a quite different attack to compliance testing is required. Typically, observed values need to exceed the stated target goals for standard statistical methods to conclude compliance. The inherent difficulty with existing tests is trying to demonstrate compliance when full recovery is expected to be at best (and at worst) exactly equal the target goals.

Alternative Decision Rules for Compliance

Establishing a Multidimensional Decision Rule

Instead of using existing statistical tests which have proven ineffectual for compliance testing (i.e., Table 1), statistical tests tailored to the purpose were constructed. The test criteria were based on reasonable properties for the annual survival estimates post-2000 under compliance. It seemed reasonable to expect under compliance, the post-2000 data may have some or all of the following properties:

1. The slope of a linear regression of annual survival versus year of the form

$$\hat{S}_i = \alpha + \beta t_i$$

   would have a positive slope (i.e., $\beta > 0$).

2. The mean survival post-2000 would be greater than the mean survival pre-2000 (i.e., $\mu_{\text{Post}} > \mu_{\text{Pre}}$).

3. Some of the annual survival estimates $(\hat{S}_i, i = 1, \ldots, 10)$ during the post-2000 period would equal or exceed the target performance level of $\mu_{\text{Pre}} + \Delta$.

4. The asymptote (γ) of a hyperbolic curvilinear line

$$\hat{S}_i = \frac{\gamma t_i}{\Psi + t_i}$$

   describing the relationship between survival over time would equal or exceed the target performance level, i.e., $\hat{\gamma} \geq \mu_{\text{Pre}} + \Delta$.

5. Mean survival during the period 2006-2010 would equal or exceed mean survival during the period 2001-2005, i.e., $\mu_{2006+} \geq \mu_{2001+}$.

A multivariate decision rule was empirically constructed using these multiple criteria which had a probability of α of rejecting the null hypotheses of no compliance when true but a high power of concluding the alternative hypothesis of compliance if compliance was indeed achieved.

In constructing the multivariate decision rule, a multidimensional critical area of size α had to be specified under the null hypothesis of no improvement (i.e., $\mu_{\text{Post}} = \mu_{\text{Pre}}$). To construct the α-critical field, Monte Carlo simulations were performed. Two sets of simulations were conducted, (1) under H_o: Noncompliance (i.e., $\mu_{\text{Pre}} = \mu_{\text{Post}}$) and (2) under H_a: Compliance when the target for survival of $\mu_{\text{Pre}} + \Delta$ was achieved in year 2010. For each simulation, 6 years of fixed pre-2000 survivals and 10 years of random survivals under compliance were generated and the test statistics computed. These multivariate test results were when binned into mutually exclusive and exhaustive cells within the hyperspace defined by the ranges of the individual test criteria. A minimum of 10,0000 simulations were done under both $\mathrm{H_o}$ and $\mathrm{H_a}$ conditions for a given set of test criteria. The test criteria were so written that they were monotonically increasing in value as $\mathrm{H_a}$ became more realized (i.e., nonrecovery versus recovery, recovery by year 10 versus recovery by year 1). Hence, one "corner" of the hypercube was distinctly associated with strong evidence for compliance. Starting in that corner, bins were summed from the most frequently occurring cells under $\mathrm{H_a}$ to the least frequent. This summary was allowed to continue until α 100 percent of the area of the $\mathrm{H_o}$ hypercube had been achieved. In so doing, a critical field has been established that has the probability of α of occurring under $\mathrm{H_o}$ but has a high probability of occurring under $\mathrm{H_a}$. The critical field is then defined by the individual test conditions that define that multidimensional space.

Several alternative test criteria were considered in devising this multidimensional test of compliance. The test criteria correspond to the five data characteristics considered to be reasonable properties of a system in compliance. The test criteria were as follows:

1. Test of $\begin{array}{l}\mathrm{H_o}: \ \beta \le 0 \\ \mathrm{H_a}: \ \beta > 0\end{array}$

   using $t_1 = \dfrac{\hat{\beta} - 0}{\sqrt{\hat{V}ar(\hat{\beta})}}$ and where $P_1 = P(t_{n-2} \le t_1)$. A weighted linear regression was performed for the model $\hat{S}_i = \alpha + \beta t_i$. The mean survival of the pre-2000 year was used for $\hat{S}_0$ at $t = 0$ with a weight of n_{Pre}, then number of pre-2000 years of annual survival estimates. For the post-2000 annual survival estimates, they were given equal weights of one.

2. Test of $\begin{array}{l}\mathrm{H_o}: \ \mu_{\mathrm{Post}} \le \mu_{\mathrm{Pre}} \\ \mathrm{H_a}: \ \mu_{\mathrm{Post}} > \mu_{\mathrm{Pre}}\end{array}$

   using $t_2 = \dfrac{\hat{\bar{S}}_{\mathrm{Post}} - \hat{\bar{S}}_{\mathrm{Pre}}}{\sqrt{\dfrac{s_2^2}{n_2} + \dfrac{s_1^2}{n_1}}}$ and where $P_2 = P\left(t_{n_1+n_2-2} \le t_2\right)$.

3. Count (C_3) of the number of post-2000 survival estimates whose values are $\ge \hat{\bar{S}}_{\mathrm{Pre}} + \Delta$. The value C_3 has the range $0,1,\ldots,10$.

4. Test of $\begin{array}{l}\mathrm{H_o}: \ \gamma \le \hat{\bar{S}}_{\mathrm{Pre}} \\ \mathrm{H_a}: \ \gamma > \hat{\bar{S}}_{\mathrm{Pre}}\end{array}$

using $Z_4 = \frac{\hat{\gamma} - \hat{\bar{S}}_{\text{Pre}}}{\sqrt{\widehat{Var}(\hat{\gamma}) + \frac{s_2^2}{n_2}}}$ and where $P_4 = P(Z \leq Z_4)$. Here, γ is the asymptote of a hyperbolic curve fit to the post-2000 data.

5. Test of $\begin{array}{l} H_o: \mu_{2006+} \leq \mu_{2001+} \\ H_a: \mu_{2006+} > \mu_{2001+} \end{array}$

using $t_5 = \frac{\hat{\bar{S}}_{2006+} - \hat{\bar{S}}_{2001+}}{\sqrt{\frac{s_1^2}{n} + \frac{s_2^2}{n}}}$ and where $P_5 = P(t_{2n-2} \leq t_5)$ when

μ_{2001+} is the mean for year 2001-2005 and μ_{2006+} is the mean for years 2006-2010.

Letting $P_1', P_2', C_3', P_4',$ and P_5' be the critical values for an α -level test of compliance based on Monte Carlo simulations, compliance would be concluded if

$$\begin{array}{l} P_1 \geq P_1', \\ P_2 \geq P_2', \\ C_3 \geq C_3', \\ P_4 \geq P_4', \\ P_5 \geq P_5'. \end{array}$$

Each of the individual criteria would need to exceed their separate critical values to conclude compliance significant at α = 0.05.

Monte Carlo Results

Monte Carlo simulations were performed using a variety of test criteria combinations (i.e., 1, . . ., 5 of Section 2.2.1). The purpose of the simulations was to determine whether various multidimensional rules provided greater statistical power than the univariate compliance tests already examined (Table 1). A sample of possible rule combinations and their statistical power to detect compliance when it indeed occurs is presented in Table 2. For comparison, power of these new tests is presented along with Rule 1 from Section 2.1.1 based on the specifications in the BiOp. To date, a combination of criteria 1, 2, and 4 (i.e., last column of Table 2) provides uniformly greater power than the BiOp rule and any other univariate methods tested. For example, should compliance in yearling chinook salmon survival between Lower Granite and Bonneville dams be achieved in the year 2010, the BiOp rule had a power of $1-\beta$ = 0.200 versus the new multivariate rule with a power of $1-\beta$ = 0.655. Should compliance be achieved in year 2001, statistical power is 0.810 versus 0.738 for the new multivariate rule versus BiOp rule, respectively. The critical values for the joint rule using criteria 1, 2, and 4 are, respectively,

$$P_1' = 0.85$$
$$P_2' = 0.74$$
$$P_4' = 0.82.$$

Observed P-values have to exceed each of these respective critical values to conclude compliance using this multivariate rule.

Results to date suggest this multivariate approach to compliance testing can provide objective criteria with known Type I error rates. Furthermore, the multivariate testing criteria, by using more information, can provide more statistically powerful tests of compliance than any univariate tests alone. Additional simulations are being performed to determine whether additional statistical power can be achieved by incorporating 4 or 5 of the test criteria.

Progress Rules

Initial Approach Using Standard Statistical Methods

Decision Rules

Statistical progress testing in years 2005 and 2008 were again initially conceptualized as standard statistical tests of one or more null hypotheses. Standard tests would be performed at some α -level to draw conclusions concerning progress in ultimately achieving compliance with

Table 2. Statistical power to conclude compliance in 2010 for yearling chinook salmon survival from Lower Granite to Bonneville at α = 0.05 under various recovery scenarios.

Scenario		Original BiOp Test	Multiple Test Criteria				
			1,2,5	1,4,5	2,4,5	1,4	1,2,4
No improvement		0.0025	0.05	0.05	0.05	0.05	0.05
Recovery by year	2010	0.200	0.575	0.534	0.569	0.621	0.655
Of size Δ	2009	0.220	0.620	0.578	0.619	0.678	0.715
	2008	0.268	0.657	0.610	0.657	0.725	0.766
	2007	0.331	0.676	0.625	0.679	0.760	0.805
	2006	0.387	0.671	0.615	0.678	0.784	0.834
	2005	0.434	0.628	0.567	0.634	0.797	0.851
	2004	0.504	0.573	0.511	0.580	0.798	0.858
	2003	0.601	0.513	0.450	0.521	0.789	0.855
	2002	0.665	0.450	0.387	0.456	0.767	0.841
	2001	0.738	0.388	0.323	0.388	0.725	0.810

BiOp performance measures. As in the previous section on compliance testing, a good progress rule would have a low probability of concluding progress if the system was not improving but a high probability of indicating progress if improvement has indeed occurred. Therefore, standard statistical tests were evaluated in the hopes of identifying satisfactory progress rules.

Five alternative tests of progress were initially evaluated; these tests were as follows:

Rule #1

Simple decision rule using

Test 1 H_o: $\beta \le 0$

H_a: $\beta > 0$

Progress would be concluded is H_o is rejected at a significance level of α. In performing this test, three forms of linear regression were considered:

1a. Ordinary linear least squares on years 2001+ (OLS).

1b. Linear regression, fixing the intercept at the value of $\hat{\bar{S}}_{Pre}$ (FA).

1c. Weighted linear least squares where data for year 0 was set at $\hat{\bar{S}}_{Pre}$ with weight 6; all post-2000 years were given identical weights of 1 (WR).

Rule #2

Joint decision rule using

Test 1 H_{o1}: $\mu_{Post} - \mu_{Pre} \le 0$

H_{a1}: $\mu_{Post} - \mu_{Pre} > 0$

Test 2 H_{o2}: $\alpha + \beta(2005 \text{ or } 2008) \le 0$

H_{a2}: $\alpha + \beta(2005 \text{ or } 2008) > 0$

Progress would be concluded if H_{o1} is rejected and H_{o2} rejected, each at a significance level of α.

Rule #3

Joint decision rule using

Test 1 H_{o1}: $\mu_{Post} - \mu_{Pre} \le 0$

H_{a1}: $\mu_{Post} - \mu_{Pre} > 0$

Test 2 H_{o2}: $\alpha + \beta(2005 \text{ or } 2008) \ge 0$

H_{a2}: $\alpha + \beta(2005 \text{ or } 2008) < 0$

Progress would be concluded if H_{o1} is rejected and H_{o2} not rejected, each at a significance level of α.

Rule #4
Joint decision rule using

Test 1 $H_{o1}: \mu_{Post} - \mu_{Pre} \geq 0$
$H_{a1}: \mu_{Post} - \mu_{Pre} < 0$
Test 2 $H_{o2}: \alpha + \beta(2005 \text{ or } 2008) \leq 0$
$H_{a2}: \alpha + \beta(2005 \text{ or } 2008) > 0$

Progress would be concluded if H_{o1} is not rejected and H_{o2} is rejected, each at a significance level of α.

Rule #5
Simple decision rule using

Test 1 $H_o: \mu_{Post} - \mu_{Pre} \leq 0$
$H_a: \mu_{Post} - \mu_{Pre} > 0$

Progress would be concluded is H_o is rejected at a significance level of α.

Monte Carlo Results
Monte Carlo simulations were performed to evaluate the Type I error rate under no recovery and the statistical power of concluding progress when the performance standards would ultimately reach compliance by year 2010. Tests of progress were conducted for years 2005 and 2008 under different trajectories for compliance. Scenarios were simulated where survival rates reached mean compliance levels $1, 2, \ldots, 10$ years post-2000. In testing for progress, only the data to 2005 or 2008 were used in the analyses.

Tables 3 and 4 provide Monte Carlo results on Rules 1-5 for progress using data through 2005 to test for progress. Of all the rules evaluated, Rule 1 using weighed regression had the highest statistical power to correctly identify progress when it was indeed occurring. Even for that rule, statistical power never exceeded 0.673. Across the rules, weighted regression outperformed ordinary least squares or fixing the intercept (i.e., α) at the pre-2000 mean.

Tables 5 and 6 provide Monte Carlo results on Rules 1-5 for progress testing using the survival data through 2008. Of all the decision rules evaluated, Rule 1 with weighted regression had the highest chance of correctly identifying progress in 2008. Rule 1 had a maximum power of 0.749 of correctly identifying progress where the survivals were improving at a rate that would reach compliance by year 2002. Power dropped to 0.433 of correctly identifying progress if the survivals were on a trajectory of reaching compliance by the year 2010. Rules 3 and 5 had the exact same performance because testing hypotheses H_{02} in Rule 3 contributed nothing to the performance of Rule 3. That left Rules 3 and 5 identical in specification.

Maximum powers of 0.673 and 0.749 of correctly identifying progress in year 2005 and 2008 by classical means suggest alternative decision rules for assessing progress are needed.

Multidimensional rules for assessing progress will therefore be investigated analogous to those reviewed for compliance testing.

Alternative Decision Rules for Progress

Establishing a Multidimensional Decision Rule

A similar multidimensional approach to progress testing was used as was proposed for compliance testing. At the 2005 and 2008 "check-in," it might be expected that if progress has been achieved, several traits should be exhibited in the monitoring data. Among the traits anticipated of the post-2000 data include the following:

Table 3. Estimated probabilities of concluding progress in yearling chinook salmon smolt survival from Lower Granite to Bonneville Dam at α = 0.10. Simulations were conducted under no improvement (i.e., Δ = 0) and prescribed improvement (i.e., Δ) from 1 to 10 years after the year 2000. Decision Rules 1 and 2 were evaluated at the 2005 "check-in."

		Rule 1			**Rule 2**			
Scenario		**OLS**	**FA**	**WR**	**OLS**	**FA**	**WR**	**Expectation**
No improvement		0.126	0.013	0.069	0.010	0.012	0.002	α = 0.10
Recovery by year	2010	0.228	0.084	0.256	0.038	0.053	0.056	1-B increasing ↓
of size Δ	2009	0.216	0.083	0.271	0.045	0.060	0.061	
	2008	0.230	0.077	0.274	0.043	0.055	0.056	
	2007	0.261	0.093	0.332	0.054	0.077	0.078	
	2006	0.285	0.125	0.415	0.074	0.102	0.105	
	2005	0.293	0.161	0.480	0.145	0.172	0.178	
	2004	0.314	0.207	0.586	0.168	0.202	0.208	
	2003	0.257	0.268	0.673	0.242	0.290	0.297	
	2002	0.178	0.228	0.646	0.276	0.360	0.367	
	2001	0.126	0.212	0.628	0.298	0.393	0.407	

Table 4. Estimated probabilities of concluding progress in yearling chinook salmon smolt survival from Lower Granite to Bonneville Dam at α = 0.10. Simulations were conducted under no improvement (i.e., Δ = 0) and prescribed improvement (i.e., Δ) from 1 to 10 years after the year 2000. Decision Rules 3-5 were evaluated at the 2005 "check-in."

		Rule 3			**Rule 4**				
Scenario		**OLS**	**FA**	**WR**	**OLS**	**FA**	**WR**	**Rule 5**	**Expectation**
No improvement		0.015	0.015	0.015	0.062	0.044	0.049	0.015	α = 0.10
Recovery by year	2010	0.075	0.075	0.075	0.178	0.145	0.173	0.075	1-B increasing ↓
of size Δ	2009	0.075	0.075	0.075	0.194	0.162	0.187	0.075	
	2008	0.072	0.072	0.072	0.231	0.179	0.203	0.072	
	2007	0.095	0.095	0.095	0.231	0.203	0.227	0.095	
	2006	0.124	0.124	0.124	0.306	0.284	0.315	0.124	
	2005	0.198	0.198	0.198	0.405	0.384	0.419	0.198	
	2004	0.237	0.237	0.237	0.443	0.451	0.493	0.237	
	2003	0.329	0.329	0.329	0.469	0.515	0.548	0.329	
	2002	0.430	0.430	0.430	0.447	0.522	0.548	0.430	
	2001	0.537	0.537	0.537	0.376	0.489	0.515	0.537	

Table 5. Estimated probabilities of concluding progress in yearling chinook salmon smolt survival from Lower Granite to Bonneville Dam at $\alpha = 0.10$. Simulations were conducted under no improvement (i.e., $\Delta = 0$) and prescribed improvement (i.e., Δ) from 1 to 10 years after the year 2000. Decision Rules 1 and 2 were evaluated at the 2008 "check-in."

		Rule 1			Rule 2			
Scenario		**OLS**	**FA**	**WR**	**OLS**	**FA**	**WR**	**Expectation**
No improvement		0.113	0.007	0.044	0.001	0.002	0.002	$\alpha = 0.10$
Recovery by year	2010	0.266	0.123	0.443	0.016	0.033	0.033	1-B increasing ↓
of size Δ	2009	0.292	0.157	0.469	0.037	0.051	0.051	
	2008	0.384	0.243	0.582	0.035	0.057	0.057	
	2007	0.378	0.274	0.656	0.048	0.075	0.074	
	2006	0.387	0.346	0.712	0.068	0.101	0.097	
	2005	0.315	0.334	0.715	0.101	0.134	0.132	
	2004	0.272	0.391	0.745	0.109	0.163	0.156	
	2003	0.218	0.374	0.735	0.203	0.273	0.266	
	2002	0.160	0.349	0.749	0.217	0.321	0.311	
	2001	0.113	0.358	0.741	0.238	0.395	0.385	

Table 6. Estimated probabilities of concluding progress in yearling chinook salmon smolt survival from Lower Granite to Bonneville Dam at α = 0.10. Simulations were conducted under no improvement (i.e., Δ = 0) and prescribed improvement (i.e., Δ) from 1 to 10 years after the year 2000. Decision Rules 3-5 were evaluated at the 2008 "check-in."

		Rule 3			Rule 4				
Scenario		**OLS**	**FA**	**WR**	**OLS**	**FA**	**WR**	**Rule 5**	**Expectation**
No improvement		0.014	0.014	0.014	0.034	0.023	0.027	0.014	α = 0.10
Recovery by year	2010	0.061	0.061	0.061	0.298	0.287	0.315	0.061	1-B increasing ↓
of size Δ	2009	0.077	0.077	0.077	0.372	0.359	0.393	0.077	
	2008	0.082	0.082	0.082	0.418	0.414	0.453	0.082	
	2007	0.101	0.101	0.101	0.472	0.481	0.522	0.101	
	2006	0.144	0.144	0.144	0.493	0.530	0.551	0.144	
	2005	0.180	0.180	0.180	0.526	0.592	0.606	0.180	
	2004	0.231	0.231	0.231	0.514	0.624	0.638	0.231	
	2003	0.348	0.348	0.348	0.530	0.645	0.643	0.348	
	2002	0.408	0.408	0.408	0.510	0.684	0.678	0.408	
	2001	0.537	0.537	0.537	0.416	0.657	0.646	0.537	

1. The slope of a linear regression of annual survival versus year of the form

$\hat{S}_i = \alpha + \beta t_i$

   would have a positive slope (i.e., $\beta > 0$).

2. Mean survival post-2000 would be greater than the mean survival pre-2000 (i.e., $\mu_{\text{Post}} > \mu_{\text{Pre}}$).

3. Some of the annual survival estimates $(\hat{S}_i; i = 1, \ldots)$ during the post-2000 period would equal or exceed the pre-2000 mean of μ_{Pre}.

4. The projection of survival at time of check-in under a linear model of the form

$$\hat{S}_i = \alpha + \beta t_i$$

   would be greater than the pre-2000 mean (e.g., $\alpha + \beta(2005) > \mu_{\text{Pre}}$).

A multivariate decision rule was empirically constructed using these multiple criteria which had a probability of α of rejecting the null hypotheses of no improvement when true but a high power of concluding progress if progress was indeed occurring.

Monte Carlo methods were used to construct an α-critical field under the null hypotheses of no improvement but which had a high probability of concluding progress if it occurred. The test criteria were so written that they were monotonically increasing under the state of survival improvements. One "corner" of the hypercube was therefore associated with strong evidence of progress. The critical field used in rejecting the null hypothesis of no progress was therefore in this "corner."

Several alternative test criteria were considered in devising this multidimensional test of progress. The test criteria correspond to the four data characteristics considered to be reasonable properties of a system in progress. These test criteria were the following:

1. Test of $\begin{array}{l} H_o: \ \beta \le 0 \\ H_a: \ \beta > 0 \end{array}$

   using $t_1 = \dfrac{\hat{\beta} - 0}{\sqrt{\widehat{Var}(\hat{\beta})}}$ and where $P_1 = P\left(t_{n-2} \le t_1\right)$. A weighted linear regression was performed for the model $\hat{S}_i = \alpha + \beta t_i$. The mean survival of the pre-2000 year was used for $\hat{S}_0$ at $t = 0$ with a weight of n_{Pre}, the number of pre-2000 years of annual survival estimates. For the post-2000 annual survival estimates, they were given equal weights of one.

2. Test of $\begin{matrix} H_o: \ \mu_{\text{Post}} \le \mu_{\text{Pre}} \\ H_a: \ \mu_{\text{Post}} > \mu_{\text{Pre}} \end{matrix}$

using $t_2 = \dfrac{\hat{\bar{S}}_{\text{Post}} - \hat{\bar{S}}_{\text{Pre}}}{\sqrt{\dfrac{s_2^2}{n_2} + \dfrac{s_1^2}{n_1}}}$ and where $P_2 = P\left(t_{n_1+n_2-2} \le t_2\right)$.

3. Count (C_3) of the number of post-2000 survival estimates whose values are $\ge \hat{\bar{S}}_{\text{Pre}}$. The value C_3 has the range $0,1,\ldots.$

4. Test of $\begin{matrix} H_o: \ \gamma \le \hat{\bar{S}}_{\text{Pre}} \\ H_a: \ \gamma > \hat{\bar{S}}_{\text{Pre}} \end{matrix}$

using $Z_4 = \dfrac{\gamma - \left(\hat{\bar{S}}_{\text{Pre}}\right)}{\sqrt{\hat{Var}(\hat{\gamma}) + \dfrac{s_2^2}{n_2}}}$ and where $P_4 = P\left(Z \le Z_4\right)$. Here, γ is the asymptote of a hyperbolic curve fit to the post-2000 data.

Letting $P_1', P_2', C_3',$ and P_4' be the critical values for an α -level test of progress based on Monte Carlo simulations, progress would be concluded if

$$\begin{aligned} P_1 &\ge P_1', \\ P_2 &\ge P_2', \\ C_3 &\ge C_3', \\ P_4 &\ge P_4'. \end{aligned}$$

Each of the individual criteria would need to exceed their separate critical values to conclude progress significant at α = 0.10.

Monte Carlo Results

Initial simulation studies indicate that multivariate decision rules do provide greater statistical power than any univariate test alone. Table 7 presents the statistical power of combined Rules 1, 2, and 4 in progress testing in years 2005 and 2008. Comparison of results reported in Tables 3 and 4 versus the 2004 check-in results of Table 7 indicate across-the-board improvements with the multivariate tests. Similarly, comparison of results reported in Tables 5 and 6 versus the 2008 check-in results of Table 7 indicate across-the-board improvements with the use of the multivariate decision rules. Actual improvements are even more dramatic, for the univariate test were performed at α = 0.10 while the multivariate tests were performed at α = 0.05. Additional studies will be conducted with Rules 1-4 to assess whether statistical power can be further improved.

Recommendations

The multivariate decision rules for progress and compliance testing are based on common-sense properties of the data expected on the road to recovery. Annual survival estimates should exceed baseline conditions (i.e., Pre-2000), show upward trends, and asymptote or equal target goals over time. By using these various properties, decision rules were built that could better detect progress or compliance than any simple criterion.

The purpose of this initial work was to demonstrate the feasibility of developing reasonable decision rules that have better statistical properties than existing criteria in the BiOp. The next step in the process should include the following.

1. Repeat analyses using updated information on baseline survival estimates.

Table 7. Estimated probabilities of concluding progress in yearling chinook salmon smolt survival from Lower Granite to Bonneville Dam at $\alpha = 0.05$. Simulations were conducted under no improvement (i.e., $\Delta = 0$) and prescribed improvement (i.e., Δ) from 1 to 10 years after the year 2000. Decision Rules 1, 2, and 4 were evaluated at the 2005 and 2008 "check-ins."

		Rules 1, 2, and 4 for Check-Ins		
Scenario		**2005**	**2008**	**Expectation**
No improvement		0.048	0.050	$\alpha = 0.05$
Recovery by year	2010	0.192	0.440	1-B increasing ↓
of size Δ	2009	0.213	0.506	
	2008	0.246	0.580	
	2007	0.283	0.652	
	2006	0.352	0.710	
	2005	0.439	0.750	
	2004	0.523	0.781	
	2003	0.584	0.789	
	2002	0.627	0.794	
	2001	0.597	0.755	

2. Expand the investigation to examine the performance of 4- or 5-dimensional rules.
3. Establish critical values for each of the in-river smolt survival performance measures listed in the BiOp.
4. Upon approval of the approach by the RM&E - Hydro Working Group, these task will be performed beginning 2003.

D. Appendix D: Estuary/Ocean Workgroup Plan

(1) Introduction

The Research, Monitoring, and Evaluation (RME) estuary/ocean subgroup (EOS) was asked by the RME Planning and Oversight Group to review implementation of RME actions related to the estuary and ocean in the Reasonable and Prudent Alternative (RPA) of the National Marine Fisheries Service's (NMFS) 2000 Federal Columbia River Power System (FCRPS) Biological Opinion (BIOP). There are additional RME elements in the Northwest Power Planning Council's (NWPPC) Fish and Wildlife Program and other regional programs, but the effort here only addresses BIOP-related RME. Specifically, the objectives are to: (1) list performance indicators and standards in the BIOP for the estuary/ocean; (2) identify estuary/ocean RME needs prescribed in the BIOP and compare these with the planned FY03 research projects to identify gaps in existing coverage; (3) and provide an action plan to fulfill RME needs not already covered by existing or planned work. The overall purpose of this document is to develop an implementation plan for BIOP-related RME actions in the estuary/ocean.

(2) Estuary/Ocean Performance Indicators and Standards

The BIOP does not contain performance indicators and standards specifically for the estuary/ ocean. Therefore, this RME assessment for the estuary/ocean will not address performance indicators or standards. RPA Action 161, however, calls for a "….monitoring and research program…to address the estuary objectives…" of the BIOP. This future effort could involve developing performance indicators and standards for the estuary/ocean.

(3) Estuary/Ocean RME Needs

As stated in the December 2000, FCRPS BIOP, "Estuarine protection and restoration must play vital roles in rebuilding the productivity of listed salmon and steelhead throughout the Columbia River basin." In keeping with this goal, the Action Agencies (AA) are working through existing Corps of Engineers (Corps) authorities and the NWPPC's sub-basin planning process to fund research, monitoring, and evaluation in the Lower Columbia River, estuary, and plume. In addition, there is much ongoing monitoring for regulatory purposes. Collectively, the projects represent the foundation to develop a collaborative, long-term program of research, monitoring, and evaluation that leverages past and present work. Thus, this BIOP-related RME plan will be developed within a regional context.

Thirteen RPA Actions in the BIOP involve estuary/ocean RME activities in varying degrees (Table X). Activities in the estuary/ocean are relevant to two RME subgroups, the Estuary/ocean and Hydro subgroups. Each of the 13 estuary/ocean RPA actions was assigned to a subgroup. Five RPA actions addressing systemwide issues that manifest themselves in the estuary/ocean, e.g., delayed mortality, were placed with the Hydro Subgroup. Six RPA actions fell under the purview of the EOS. Most of the six EOS actions address status monitoring, but as research progresses and habitat improvement projects are implemented many of the actions may evolve into action effectiveness endeavors. Finally, two RPA actions (159 and 160) involve habitat protection and restoration in the Lower Columbia River and estuary.

Projects addressing RPA actions 159 and 160 (Table X) are scheduled to be implemented in FY03 and will necessarily involve RME. The 159 habitat restoration plan will include RME guidelines. The 160 habitat restoration program will eventually be linked into the RME Plan for the basin. Actions 159 and 160, however, are not included in this RME implementation plan because they are inherently planning and implementation actions associated with on-the-ground habitat restoration. While we recognize that project-specific monitoring to determine effectiveness will be required as habitat projects are implemented, this aspect of RME should be addressed during project planning and linked to the larger, overall RME effort.

Table X. Summary of RPA actions related to the estuary/ocean with lead RME subgroup and RME category (SM = status monitoring; CU = critical uncertainty; AE = action effectiveness; and N/A = not applicable).

Action No.	Statement	Lead Sub-Gp	RME Category
158	During 2001, the Corps and BPA shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS system on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.	Estuary/ ocean	SM
159	BPA and the Corps, working with LCREP and NMFS, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.	N/A	N/A
160	The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the Columbia River. The Corps shall seek funds for the Federal share of the program, and BPA shall provide funding for the non-Federal share. The Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in LCREP, Action 2.	N/A	N/A
161	Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion.	Estuary/ ocean	SM
162	During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations	Estuary/ ocean	SM
185	The Action Agencies shall continue to fund and expand, as appropriate, fish marking and recapturing programs aimed at defining juvenile migrant survival for both transported and non-transported migrants and adult returns for both groups. These studies shall also compare the SARs of transported and non-transported fish to calculate the differential delayed mortality (D), if any, of transported fish.	Hydro	CU
186	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for comparative evaluations of the behavior and survival of transported and downstream migrants to determine whether causes of D can be identified for the reach between Bonneville Dam and the mouth of the Columbia River.	Hydro	CU

Action No.	Statement	Lead Sub-Gp	RME Category
187	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies and analyses to evaluate relationships between ocean entry timing and SARs for transported and downstream migrants.	Hydro	CU
193	The Action Agencies shall investigate state-of-the-art, novel fish detection and tagging techniques for use, if warranted, in long-term research, monitoring, and evaluation efforts.	Hydro	SM and CU
194	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the Lower Columbia River and plume. This model will characterize potential changes to estuarine habitat associated with modified hydrosystem flows and the effects of altered flows where they meet the California Current to form the Columbia River plume.	Estuary/ ocean	AE/SM
195	The Action Agencies shall investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.	Hydro	SM
196	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary. These studies support the actions to develop criteria for estuarine restoration (Action 158), restoration planning (Action 159), and implementation (Action 160) in Section 9.6.2.2.	Estuary/ ocean	SM
197	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.	Estuary/ ocean	SM

(3-a) Estuary/Ocean Status Monitoring

(a) Summary of RME Needs

Six RPA Actions assigned to the EOS address status monitoring (Actions 158, 161, 162, 194, 196, and 197). In particular, Actions 158 and 162 entail research to better understand fundamental salmonid biology and ecology in the estuary, including impacts of the FCRPS, with a goal of developing science-based habitat preservation and restoration criteria. Action 161 specifically requires that the AA establish a RME program for the estuary/ocean, which is closely coordinated with the Estuary Partnership's monitoring and research efforts. Action 194 addresses both status monitoring and action effectiveness. It specifically requires that the AA establish a numerical, physical model of the estuary and plume that can be used to characterize potential changes in physical habitat important to salmon in relation to natural and anthropogenic modification of the estuarine environment as well as to assess the effectiveness of restoration efforts in the estuary. But, since the ultimate application of Action 194 is action effectiveness, that is where it is discussed (Section 3.2.1). Actions 196 and 197 require the AA to work to provide research funding to develop an understanding of adult and juvenile salmonid use of the e stuary and plume, respectively.

(b) Summary of Estuary/Ocean RME Projects

Nine ongoing or proposed projects are pertinent for the estuary/ocean RME subgroup to review for a RME gap assessment of RPA Actions 158, 161, 162, 194, 196, and 197 (Table X+1). Five are ongoing Corps projects, two are ongoing NWPPC Fish and Wildlife Program projects, and three are proposed NWPPC Fish and Wildlife Program projects (Table X+1). These projects sometimes apply to one or more RPA actions (Table X+1). In the following section, we describe the RPA action, review the projects that apparently address the action, and assess and gaps in coverage. Recommendations to fill any gaps are listed at the end of the document.

There are other ongoing projects in the lower river and estuary that involve RME but are not directly applicable to the AA's RME effort. We mention them here for the purpose of awareness. Many of these are water quality monitoring efforts by various local, state, and federal agencies, such as Oregon Department of Environmental Quality's statewide network of ambient monitoring sites, U.S. Geological Survey's National Ambient Water Quality Assessment Program, and Corps monitoring of temperature and total dissolved gas. In addition, the U.S. Geological Survey is performing a sediment core analysis; a NOAA Fisheries Technical Recovery Team is identifying recovery goals for all listed evolutionary significant units of salmonids; Portland State University, Oregon State University, and University of Washington are surveying invasive species distribution and abundance in the Lower Columbia River for the U.S. Coast Guard and U.S. Fish and Wildlife Service; Sea Resources, a local conservation organization, has a grant from the Columbia Land Trust and Salmon Recovery Funding Board of the State of Washington to develop a habitat model to study the effects of tide gate removal on the Chinook River; and the Columbia River Estuary Study Taskforce has funding from the Estuary Partnership to monitor the effects of tide gate removal. Where appropriate, tracking and following of these and other projects at the RME program level will be necessary to ensure that the program considers all related RME activities.

Table X+1. Current and proposed Corps and NWPPC Fish and Wildlife Program (BPA funded) projects addressing RPA actions related to estuary/ocean subgroup RME status monitoring and action effectiveness research. Coverage does not imply adequacy to satisfy an RPA action, only that research is being conducted on the general topic matter of the action. See Table X for the RME category (status monitoring or action effectiveness) of the RPA actions.

			RPA Action Coverage					
Project No.	**Descriptor**	**Partici-pants**	**158**	**161**	**162**	**194**	**196**	**197**
Corps AFEP Program -- Ongoing								
EST-P-02-01	A study to estimate salmonid survival through the estuary using acoustic tags	NMFS, PNNL		**X**			**X**	**X**
EST-P-02-02	Estuarine habitat and juvenile salmon – current and historic linkages in the Lower Columbia River and estuary	NMFS, ODFW, OSU, OHSU	**X**	**X**		**X**	**X**	
EST-P 02-03	Evaluation of the relationship among time of ocean entry, physical and biological characteristics of the estuary and plume environment, and adult return rates	NMFS						**X**

			RPA Action Coverage					
Project No.	**Descriptor**	**Partici-pants**	**158**	**161**	**162**	**194**	**196**	**197**
BPS-00-11	Sampling PIT tagged juvenile salmonids migrating in the Columbia River Estuary	NMFS	**(c)**				**X**	
TPE-W-00-01	Evaluation of migration and survival of juvenile steelhead and fall chinook following transportation	OSU	**(d)**				**X**	
NWPPC F&W Program – Ongoing								
1998-014	Survival and growth of juvenile salmon in the Columbia River plume	NMFS, OSU, OHSU	**X**	**X**	**X**	**X**	**X**	**X**
2002-012	Lower Columbia River habitat mapping	LCREP, UW, Earth Designsand Science Wkgrp.	**X**			**X**		
NWPPC F&W Program – Proposed and High Priority for Funding								
30001	Historic habitat opportunities and food-web linkages of juvenile salmon in the Columbia River estuary: implications for managing flows and restoration	NMFS, OSU, OHSU	**X**	**X**	**X**	**X**	**X**	
30015	Lower Columbia River and estuary ecosystem monitoring	LCREP, Science Wkgp		**X**				
35046	Estimate juvenile salmon residence in the Columbia River plume and continental shelf using micro-acoustic transmitters	NMFS, Kin- tama				**X**	**X**	**X**

The number of current projects and the prospect for growth in the future necessitate program-level coordination. Within the RME program, information leveraging across projects will be essential for cost effective RME. Also, multiple funding sources and funding mechanisms will be key to long-term success in establishing useful RME.

RPA Action 158 – Estuarine Habitat Inventory, Limiting Factors, and Restoration

Description

This RPA action is very broad in its goals. It calls for the AA "to seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration."

The RME aspect of this action is that it implicitly seeks to provide a scientific basis to protect and restore salmonid habitats in the Lower Columbia River and estuary. Since habitat restoration here is thought to have the potential to improve salmonid survival (Karieva et al. 2000), historic and current baseline conditions will be needed to provide context to evaluate the results of habitat improvement activities. Furthermore, the basic ecology of salmonids in the lower river and estuary is poorly understood. The research prescribed in Action 158 is fundamental to achieving effective habitat protection and restoration.

Current and Proposed Projects
The formal "action plan" called for in Action 158 has not been completed yet. However, several ongoing and proposed research projects address particular elements of Action 158 as follows:

(a) Habitat Inventory. The Lower Columbia River Estuary Partnership's (Estuary Partnership) habitat mapping project (2002-012, Table X+1) uses several types of remotely sensed imagery of different spatial and spectral qualities, all linked spatially within a geographic information system. The imagery is used to extrapolate estuary-wide habitat cover from a limited number of ground observations made by field teams. Imagery types include two Landsat 7 TM scenes, IRS satellite imagery, airborne digital video imagery, and 19-band compact airborne spectrographic imager hyperspectral imagery. After the habitat classification process is complete, this project will provide a detailed inventory of *current* estuarine and Lower Columbia River habitat types.

In another ongoing project (EST-P-02-02, Table X+1), NMFS is reconstructing selected historical habitat maps of the Lower Columbia River and estuary. Topographic maps and land survey notes compiled from 1868 to 1901 are being analyzed. They will be used to hypothesize about possible historic juvenile salmonid use patterns. This will provide linkage between historic and current habitat conditions.

The two mapping efforts will provide important comparative change data. They are being tracked through the Estuary Partnership's Science Workgroup.

(b) Biological and Physical Models. A numerical model of estuary circulation is being developed by the Oregon Health and Science University/Oregon Graduate Institute. This model, called ELCIR (Eulerian - Lagrangian CIRCulation), receives data from a network of stations (referred to as CORIE) where temperature, salinity, conductivity, turbidity, etc., are monitored. Also, physical numerical model work was proposed to evaluate the relationship between salmonid rearing opportunities and historic habitat modifications (30001, Table X+1). Biological-physical modeling was also proposed for the plume environment (35046, Table X+1). Similar modeling for the estuary, however, is apparently not in the queue. In addition, the Corps has several models of the estuary's physical environment.

(c) Limiting Factors. Assuming research shows that estuary conditions are limiting to salmonid survival, then limiting factors in the context of estuary RME basically refer to the question: Restoration of which ecosystem functions and habitats would most benefit diversity and adequacy of salmonid usage in the estuary and, hence, result in increased resilience and survival of salmon stocks? The ongoing research by NMFS and others (EST-P-02-02 and 30001, Table X+1) is designed to address the limiting factors issue.

(d) FCRPS Impacts. The FCRPS has altered the natural hydrograph, affecting flows, floodplain dynamics, sediment loads, and input of macro-detritus to the environment downstream of Bonneville Dam. Many ongoing and proposed projects (1998-014, 30001, 35046, EST-P-02-02) plan to investigate the functional linkage between these FCRPS impacts and salmon survival in Lower Columbia River, estuary, and plume habitats (Table X+1). Workshops and modeling efforts will be important tools in these efforts.

(e) Habitat Restoration Criteria. Habitat protection, conservation, and restoration guidelines were formulated during the Estuary Habitat Workshop (June, 2001 in Astoria, Oregon) and were subsequently adopted by the Estuary Partnership's Science Workgroup. In addition, future research findings by NMFS and others (EST-P-02-02 and 30001, Table X+1) will be essential to refine the existing science-based restoration criteria. Organizations interested in on-the-ground restoration and conservation actions will use these findings to establish restoration criteria as part of the habitat restoration plan called for in Action 159.

Gap Analysis

There are several gaps in the coverage of Action 158. The specific action plan called for in RPA Action 158 has not been drafted and the prescribed biological modeling is not being conducted at this time. Any eventual biological model should involve bio-physical coupling and include shallow-water, tidal habitats. Also, while some excellent research is ongoing or proposed, it is unclear if applicable results will be available soon enough for pending decisions on restoration projects to meet BIOP requirements. The degree to which Action 158 is being addressed will need to be re-evaluated after project reports are delivered. When decisions must be made before research findings are available, post-implementation monitoring and evaluation will be essential.

RPA Action 161 – Estuary RME Program

Description

Action 161 specifically states, "….fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion." Management Plan Action 28, from the Estuary Partnership's *Comprehensive Conservation and Management Plan*, dated June 1999, states: "Implement the Estuary Program['s] long term monitoring plan." The Estuary Partnership's (LCREP) monitoring strategy is explained in their document, *Aquatic Ecosystem Monitoring Strategy*, dated February, 1998. Through Action 161, the BIOP demonstrated the importance of building on existing forums and accomplishments to coordinate research, monitoring, and evaluation in the Lower Columbia River, estuary, and plume. The intent of Action 161, to establish a closely coordinated RME program for the estuary, is clear and is of direct importance to the RME implementation plan.

Current and Proposed Projects

Information gathered under ongoing project (EST-P-02-02, Table X+1) and proposed project (30001, Table X+1) discussed under RPA Action 158 will contribute to development of the RME program called for in Action 161, as well as constitute part of the ongoing monitoring effort. In addition, Proposal 30015 (Table X+1) by the Estuary Partnership presents a program for habitat monitoring. This proposal specifically focuses on habitats important to juvenile salmonids. Under 30015, a pilot habitat monitoring program would be implemented to develop protocols, procedures, and indicators leading to long-term habitat monitoring and evaluation requirements. A technical team will develop the methods, critique and test the methods, assess the results, and recommend future work. Based on the results, a long-term habitat monitoring program will be implemented in coordination with other interested organizations. Finally, Action 161 is being addressed in a broad sense by the very RME Plan, with its estuary/ocean component, that is currently being developed by the AA. This pilot study will be an important step to create a foundation for an estuary/ocean RME plan.

Gap Analysis

The Estuary Partnership's *Aquatic Ecosystem Monitoring Strategy* provides a solid framework and basis in which to establish a comprehensive ecosystem monitoring program for the lower river and estuary. A group of over twenty scientists worked for 2 years to develop the strategy. Some pieces have been implemented (e.g., habitat inventory, ambient monitoring, invasive species inventory), but most of the elements have not been implemented due to lack of funding. To accommodate the needs of the BIOP, some modifications would be needed, particularly in the area of fish monitoring, which is not specifically addressed in the Strategy. The Estuary Partnership's Science Work Group monitoring subcommittee could revise the strategy to better meet RPA needs, especially since the Work Group includes BIOP parties like BPA, Corps, and NMFS.

RPA Action 162 – Conceptual Model of Estuarine Ecological Relationships

Description

RPA Action 162 states, "During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations." Action 162 essentially calls for the planning and preparation phase for biological-physical modeling in the estuary. Action 162, therefore, complements Actions 158 and 194, which include development of physical and ecological models.

Current and Proposed Projects

The *Salmon at River's End* (SARE) draft report (Bottom et al. 2001) contains a conceptual model of salmon with respect to stock resilience in light of hydropower operations, identifies gaps in our knowledge, and makes recommendations of data and information needs to fill those gaps. The proposed effort in project 30001 (Table X+1) is spawned from those recommendations and is the first attempt to start filling in the gaps of knowledge identified in the SARE report. According to Proposal 30001, researchers plan to investigate ecological linkages for ESA-listed salmonids in the Lower Columbia River and estuary. The proposal includes a biological-physical modeling component. It will be necessary to finalize a definitive conceptual framework, as mandated in Action 162, to successfully develop the models prescribed in 158 and 194.

Thom et al. (2001) also developed a conceptual model of the Lower Columbia River and estuary ecosystem functionality with respect to juvenile salmonids for the Biological Assessment and Biological Opinion for the Columbia River Channel Improvements Project. At its current stage of development, the model is too generic to implement Action 162, although it could serve as an initial point of information. To be of use to Action 162, this model would have to be developed further using data from estuary research in EST-P-02-02 and elsewhere. In addition, other conceptual models of the Lower Columbia River and estuary, such as the food webs models developed by the University of Washington, are available to possibly apply to fulfill Action 162.

Gap Analysis
The SARE report provides a substantial contribution toward a definitive conceptual ecosystem model for the Columbia estuary. When SARE is finalized and if proposal 30001 is funded, then important aspects of Action 162 will seemingly be addressed. The gap or critical uncertainty is whether or not the relationship between estuarine conditions and salmonid population resilience can be established. Furthermore, models addressing adult usage are apparently lacking. Finally, it will be important to ensure that the 162 modeling efforts can be tied to similar modeling efforts upstream in the hydrosystem.

RPA Action 196 – Salmon Use of the Estuary
Description
RPA Action 196 states, "The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary. These studies support the actions to develop criteria for estuarine restoration (Action 158), restoration planning (Action 159), and implementation (Action 160)..." This action clearly expresses its relationship to other RPA actions. It complements a similar action (197) for the Columbia River plume.

Current and Proposed Projects
For the purpose of this gap assessment, we focus on the research and not funding intents of Action 196. Project EST-P-02-02 and proposal 30001 are consistent with the *research intent* of Action 196 as it applies to juvenile salmonids, but not adults. Regarding the *funding intent* of Action 196, namely to establish a long-term source of monies to research salmon use in the estuary, the RME Planning and Oversight Group determined that the funding issue was beyond the scope of the RME Gap analysis (RME meeting, October 4, 2002).

Gap Analysis
With respect to the research intent of Action 196, adult salmon research is apparently not ongoing or proposed. In general, studies are needed to increase the knowledge base for the estuary environment, such as acoustic telemetry of adult migration in the estuary. Such studies will have direct application back to regulatory, restoration, and monitoring efforts in the estuary.

RPA Action 197 – Salmon Use of the Plume
Description
RPA Action 197 says, "The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume." This action complements Action 196 regarding salmonid use of the estuary.

Current and Proposed Projects
Project 1998-014 and proposal 35046 (Table X+1) are consistent with the research intent of this Action Item. Proposal 35046 is now a joint effort between NOAA Fisheries Science Center and

Kintama Research. As such, coordination of acoustic telemetry efforts should be achieved to investigate juvenile salmonid usage of the plume and nearshore oceanic areas off the mouth of the Columbia River. Acoustic telemetry will be an important tool to estimate survival in these important habitats during the life cycle of ESA-listed fishes.

Gap Analysis
As with RPA Action 196, a gap exists as adult salmon research is called for in the Action 197, but apparently is not ongoing or proposed. Also, long-term studies are needed to increase the knowledge base for the estuary environment, which will have direct application back to regulatory, restoration, and monitoring efforts in the plume.

(3-b) Estuary/Ocean Action Effectiveness Research

(a) Summary of RME Needs
As for Status Monitoring, a needs statement for estuary/ocean RME action effectiveness will be developed for a later version of the RME Plan. For now, the BIOP RPA actions will drive estuary/ocean RME planning, and NWPPC Program elements C and D.8 will be applied where appropriate.

(b) Summary of Estuary/Ocean RME Projects
Of the six RPA Actions with the estuary/ocean subgroup as the lead, only one (Action 194) seems to address action effectiveness. In the following section, Action 194 is described, projects and proposals addressing it are discussed, gaps are assessed, and recommendations are offered.

RPA Action 194 – Physical Model of Lower Columbia River and Plume
Description
Action 194 states, “The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the Lower Columbia River and plume. This model will characterize potential changes to estuarine habitat associated with modified hydrosystem flows and the effects of altered flows where they meet the California Current to form the Columbia River plume.” Such a numerical model (not a physical scale model) may be useful to evaluate the effects of any actions to modify FCRPS operations on estuarine and nearshore circulation patterns, dynamics of the turbidity maximum, extent of the plume, etc. Action 194 complements Actions 158 and 162.

Current and Proposed Projects
One current and two proposed projects include computer modeling of the lower river and plume (Table X+1). The current project (1998-014 ocean survival of salmon, Table X+1) has an element supporting further development of ELCIRC and its associated monitoring system CORIE (see text for RPA Action 158). CORIE is a pilot environmental observation and forecasting system for the Columbia River. It integrates a real-time sensor network, a data management system and advanced numerical models. The first year of the project focused on initial validation of existing numerical models and on development of methodologies for field sampling guided by numerical models and remote sensing data. In the second and subsequent years, the balance will shift toward using appropriately data-constrained models to describe the oceanographic features of the Columbia River estuary, plume, and near-shore environment, and

their space-time variability. The CORIE modeling system integrates models and field controls. Focus is on the simulation of 3D circulation, in a region centered in the estuary and plume, but extending from Bonneville Dam to the Eastern North Pacific.

An ongoing project (EST-P-02-02, Table X+1) and a proposed project (30001, Table X+1) also includes use of the ELCIRC Model and the CORIE monitoring system. Part of this project would include using CORIE to evaluate cumulative changes in bathymetry and flow on habitat opportunities for juvenile salmon. CORIE can be inspected at: http://www.ccalmr.ogi.edu/. In addition, the Corps has numerical models of the estuary that may prove useful to address Action 194.

Gap Analysis
Ongoing research by OGI and NOAA Fisheries addresses Action 194. Therefore, there does not appear to be a gap in coverage.

(4) Estuary/Ocean RME Action Plan

The action plan to implement BIOP-related RME for the estuary/ocean entails recommendations for RME. We do not offer any guidelines because they generally are implicit in the RPA actions and adequately directed RME research is well along. In addition, as mentioned above, the Estuary Partnership's Aquatic Ecosystem Monitoring Strategy for the Lower Columbia River provides a useful approach to estuary RME that will be used when Action 161 is implemented. The EOS found that existing or proposed research was generally adequate to meet estuary/ocean RME needs, as defined by the BIOP (Table X+2). There were several instances where activities called for in RPA actions needed to be addressed explicitly. Furthermore, the AA and NOAA Fisheries currently are addressing the RME need for research on adult salmon usage of the estuary and plume.

The BIOP recognized the broad, regional nature of RME. There are existing RME efforts that can provide essential data. Therefore, implementation of BIOP-related RME will be coordinated regionally.

(5) Conclusions

To fulfill these recommendations, existing or proposed research may need to be redirected or re-emphasized. Special requests for proposals, however, will not be required, assuming the ongoing and proposed projects listed in Table X+1 are funded. The AA should continue to scrutinize project goals and objectives to eliminate potential project overlaps to most effectively leverage available monies from all available funding sources. The EOS suggests that the RME Planning and Oversight Group inform the affected researchers of these recommendations. A meeting between the EOS and estuary/ocean researchers might also be appropriate.

Table X+2. Recommendations and tasks for estuary/ocean RME activities to supplement and clarify ongoing and proposed projects in Table X+1. Note that although the content of this table pertains to BIOP-related RME, it could be expanded as appropriate in the future to accommodate an ecosystem-based approach.

Action No.	RME Category	Recommendation	Tasks	Product	Related Actions	Time-frame	Status
Action 158 Estuary Research	Status Monitoring	1. Complete the action plan called for in Action 158.	a. Draft table of contents. b. Coordinate w/ affected parties. c. Coordinate w/ the TRT for the Willamette and Lower Columbia River	Action plan	159	FY'03 due 5/03	Not started
		2. Continue the estuarine research called for in Action 158.	a. Finish the habitat inventory and mapping work. b. Continue to develop the ecological model of opportunity for salmon use. c. Apply the model to estimate how much of what habitat type is available for salmon. d. Review existing data and assess limiting factors. e. Quantify changes in flow and sediment load in the estuary attributable to FCRPS and other sources. f. Develop recommendations for restoration criteria in three areas: engineered, passive, and beneficial use.	Annual research reports	159, 161, 162, 194, 196	FY'03 to FY'05 reports due each year in Dec.	Ongoing
		3. Conduct annual or bi-annual technical workshops to present and discuss the latest research in the Lower Columbia River, estuary, and plume.	a. Establish workshop goals and objectives. b. Develop agenda. c. Coordinate and perhaps merge with an existing forum, such as the AFEP Annual Review or the Nearshore Ocean Salmon Ecology meeting.	Workshop summary	159, 194, 196, 197	FY'03 to FY'08	Ongoing

Action No.	RME Category	Recommendation	Tasks	Product	Related Actions	Time-frame	Status
		4. Evaluate numerical models for later versions of the RME Plan.	a. Identify available models. b. Compare and analyze the models relative to BIOP-related RME requirements. c. Make recommendations for model use. d. Apply model to analyze various hydrosystem management scenarios.	Research report	162, 194, 196, 197	FY'03 due 9/03	Not started
Action 161 Estuary RME Program	Status Monitoring	5. Develop, implement, and coordinate an estuary/ocean RME program.	a. Identify program planning participants, such as the LCREP Science Workgroup. b. Inventory existing monitoring work. c. Use LCREP's *Aquatic Ecosystem Monitoring Strategy* (Appendix X) as a basis to design the estuary/ocean RME program. d. Identify RME efforts beyond the BIOP. e. Develop performance indicators and standards as appropriate for physical, biological, chemical, and administrative aspects of the program. f. Coordinate with the data management subgroup to establish data management protocols to ensure access and usability of the data. g. Integrate pertinent elements of the AA's regional RME plan into the specific RME program called for in Action 161. h. Ensure that RME protocols do not jeopardize usefulness of historical data. i. Incorporate RME Program needs into the workshop in Recommendation No. 3.	Program plan and annual reports	158, 159, 162, 194, 196, 197	FY'03 to FY'08 annual reports Dec.	Not started

Action No.	RME Category	Recommendation	Tasks	Product	Related Actions	Time-frame	Status
Action 162 Conceptual Ecosystem Model	Status Monitoring	6. Develop and refine a definitive conceptual ecosystem model for the Lower Columbia River and estuary using information from ongoing research.	a. Review, compare, and contrast existing conceptual models. b. Design and build the conceptual model.	Research report	158, 161, 194, 196, 197	FY'03 model due 12/03	Not started
		7. Coordinate joint agency activities to evaluate if the results of ecosystem modeling can be tied to ongoing efforts upstream.	a. Identify upstream modeling efforts. b. Establish linkages as pertinent.	Research report	158, 161, 162, 194	FY'03 due date TBD	Not started
Action 194 Numeric Physical Model of Estuary	Action Effectiveness	8. Continue to research the biological/physical linkages necessary in a physical model of the Lower Columbia River and plume..	a. Coordinate with and use results from research in Actions 158 and 196. b. Incorporate biological/physical linkages into the model. c. Validate the model. d. Apply model to analyze various hydrosystem management scenarios.	Research reports	158, 161, 162	FY'03 to FY'08 annual reports due Dec.	Ongoing
Action 196 Estuary Usage	Status Monitoring	9. Continue efforts to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary.	a. Have dialogue among Corps, BPA, and NOAA Fisheries to resolve adult salmon usage issue.	Decision memo	158, 161, 162	FY'03 to FY'08 annual reports due Dec.	Juvenile work ongoing, adult work not started
Action 197 Plume Usage	Status Monitoring	10. Continue efforts to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.	a. Have dialogue among Corps, BPA, and NOAA Fisheries to resolve adult salmon usage issue.	Decision memo	158, 161, 162	FY'03 to FY'08 annual reports due Dec.	Juvenile work ongoing, adult work not started

Current Status of the Estuary Partnership's Efforts for Monitoring Oversight and Habitat Monitoring

The Lower Columbia River Estuary Partnership (Estuary Partnership) through its Science Workgroup developed and published the *Aquatic Ecosystem Monitoring Strategy for the Lower Columbia River* (Estuary Partnership 1998). Elements of the ecosystem-based strategy included the following monitoring activities: oversight, habitat, data management, conventional pollutants, toxic contaminants, exotic species, and primary productivity. In this appendix, we present a summary of the four phases of the monitoring and evaluation strategies (Table XX). BIOP-related RME efforts in the estuary/ocean arena will need to be coordinated with this ongoing work.

Table XX. Estuary Partnership's monitoring and evaluation strategies.

PHASES	MONITORING OVERSIGHT	DATA MANAGEMENT	CONVENTIONAL POLLUTANTS	TOXIC CONTAMINANTS	HABITAT MONITORING	EXOTIC SPECIES	PRIMARY PRODUCTIVITY, FOOD WEB
PHASE ONE	♦set up coordination structure and monitoring committee, ♦develop interagency agreements and contracts, process to identify and allocate resources, ♦begin discussions on expansion of existing programs	♦locate all existing data, ♦improve access to data, ♦heighten public awareness	♦continue existing ambient programs for temp., TDG, bacteria, DO, pH, SS, TOC, C, nutrients, ♦track TMDLs for temp and TDS, ♦explore increasing scope and number of ambient sites, ♦begin discussions on consistent bacteria standards,	♦work w/USGS to redesign NASQAN to include toxics, ♦explore expanding existing ambient programs to include toxics, ♦establish baseline sampling network for toxics in sediments, ♦ develop random network for monitoring toxics in fish tissue, ♦begin discussions on discharge monitoring stations,	♦conduct workshop on measuring biological integrity, ♦develop agreements to share habitat data with all parties, ♦ develop habitat monitoring procedures, ♦contract for special study to survey existing habitat metadata,	♦develop agreements with all involved entities to share data and develop comparable procedures for monitoring exotic species, ♦evaluate existing information on exotic species to begin developing strategy for monitoring	♦explore expanding existing ambient monitoring programs to include productivity parameters DO, pH, TOC, nutrients, chlorophyll a, and BOD, ♦work with monitoring partners to begin development of index of biotic integrity for macroinvertebrates

PHASES	MONITORING OVERSIGHT	DATA MANAGEMENT	CONVENTIONAL POLLUTANTS	TOXIC CONTAMINANTS	HABITAT MONITORING	EXOTIC SPECIES	PRIMARY PRODUCTIVITY, FOOD WEB
PHASE TWO	♦continue oversight, ♦expand ambient programs, ♦expand special projects, ♦implement phase two components, implement phase two components, ♦ensure information reaching public, ♦add extra staff as needed	♦agreements on consistent monitoring protocol and procedures and data management standards, ♦ develop strategies for linking databases, ♦all data on STORET X, ♦ track development of other relevant data	♦expand existing ambient monitoring for other parameters and more sites, ♦ conduct synoptic study of temp in mouths of tributaries, ♦further define temp TMDL, ♦facilitate adoption of consistent bacteria standard, ♦work with USACE for QA/QC for TDG	♦expand existing sites to include toxics, ♦implement sampling for toxics in sediment and fish tissue, ♦contract for special study to analyze existing data, ♦develop sampling design and conduct reconnaissance sampling for toxics in water and suspended sediments, ♦contract for special study on hot spots, ♦establish discharge monitoring stations, ♦coordinate on radionuclide monitoring	♦complete analysis of metadata, ♦begin development of habitat monitoring scheme, ♦conduct second habitat monitoring workshop, ♦contract to conduct remote sensing, ♦contract to begin habitat monitoring ♦contract for aerial photography or high-resolution video multiple spectral scanning to characterize habitat,	♦complete review of existing data and finalize monitoring strategy, ♦implement sampling program aimed at species not currently being sampled, ♦contract to evaluate impacts of introduced species, ♦ develop strategy for monitoring introduction, ♦create educational program	♦expand existing sites to include productivity parameters, ♦ develop agreements with monitoring partners to incorporate IBI into sediment sampling for toxics, ♦contract for special study of suspended particulate mater, nutrients, and primary production including interactions with macrioinvertebrates,
PHASE THREE	♦continue oversight, implement phase three monitoring components ♦begin developing five year monitoring assessment report	♦implement short term approach to managing data using Estuary Program homepage to link a networked system of databases, ♦work with DEQ, Ecology and EPA to analyze data and develop reports	♦continue expanded ambient monitoring, implement TMDL management actions for temp and TDG, ♦ contract to conduct bacterial survey at selected beaches, ♦ conduct survey of water contract recreationists, ♦conduct evaluation of data and status report	♦evaluate results and adjust sediment toxic monitoring, ♦evaluate fish tissue study and conduct statistical analysis to determine future direction, ♦ evaluate results of reconnaissance sampling and implement long term program to track trends, ♦establish continuous turbidity sampling at selected sites, ♦contract for health study of human health risks associated with consumption of contaminated organisms, ♦develop guidance on contaminated non-dredge sediments.	♦contract for system wide bathymetry, ♦contract for analysis of habitat metadata to reconstruct historical landscape patterns, ♦begin assessment of overall habitat monitoring scheme	♦implement program to monitor mechanisms of introduction, ♦develop agreements to implement ongoing program to assess impacts of introduced species, ♦ continue and expand educational efforts,	♦assess results of special study on primary production and food webs to determine if useful way to measure biological integrity, ♦develop agreements to implement long term monitoring of productivity depending on assessment, ♦complete survey of metadata to assess historic and current sampling plans, ♦conduct an assessment of food webs from benthic invertebrates through fish, ♦develop a model of primary production

PHASES	MONITORING OVERSIGHT	DATA MANAGEMENT	CONVENTIONAL POLLUTANTS	TOXIC CONTAMINANTS	HABITAT MONITORING	EXOTIC SPECIES	PRIMARY PRODUCTIVITY, FOOD WEB
PHASE FOUR	♦continue oversight, ♦implement any remaining monitoring components, ♦seek resources for and implement recommendations from 5 year monitoring assessment report	♦seek resources to implement the data recommendations from the 5 year report to possibly include totally interactive data management system	♦continue existing ambient programs ♦ implement permanent program for monitoring conventional pollutants based on recommendations of 5 year report	♦contract for study to identify trends in sediments through core sampling and analysis, ♦use cores to determine the effect of extreme hydrologic events, ♦contract to evaluate the impact of native versus hatchery fish on tissue contaminant data, ♦ contract for study of bed sediments in reservoir pools, ♦evaluate recommendations from 5-year report and adjust program	♦continue coordination of interagency habitat monitoring and assessment of data, ♦evaluate results of 5 year report and adjust existing habitat monitoring program, ♦develop and implement new strategies	♦evaluate results of 5 year report and adjust existing nonindigenous species monitoring efforts based on finding of the report	♦contract for reconstruction of history of water quality in estuary and behind selected reservoirs using diatoms in sediments, ♦contract for a reconstruction of organic matter sources for food webs using multiple stable isotopes, ♦evaluate recommendations of 5 year report and adjust monitoring efforts

E. Appendix E: Hatchery/Harvest Workgroup Plan

(1) Introduction

This appendix constitutes the plan for addressing hatchery and harvest-related research, monitoring, and evaluation (RME) called for in the National Marine Fisheries Service (NMFS) December 2000 Biological Opinion (BiOp) on the Federal Columbia River Power System (FCRPS). Specifically, this plan covers Reasonable and Prudent Alternative (RPA) items 182 and 184, which focus on hatcheries or hatchery fish, and on RPA 167, which relates to harvest.

This plan was prepared by the Hatchery/Harvest RME Workgroup, a team comprised of NMFS (NOAA Fisheries and NOAA NWFSC) and Action Agency scientists chosen for their expertise in hatchery and harvest-related issues associated with the BiOp.[7] This plan will evolve over time as analyses of needs continues, the results of current RME activities become available, and a broader review of the plan occurs.

This document is organized into four sections. Following this introduction, each of the next three sections addresses one of the three RPA Action Items covered in this plan. Section II addresses RPA 182, Section III addresses RPA 184, and Section IV addresses RPA 167. Each section begins with the Action Item as presented in the BiOp, followed by a discussion of the key questions that the Action Item was intended to address and how those questions relate to implementation of the BiOp. The next subsection identifies relevant performance indicators that will be evaluated at the scheduled BiOp check-ins, and any applicable performance standards pertinent to future assessments. The next subsection presents an overview of the actions underway in the basin that may contribute to addressing the stated needs. This overview encompasses the Action Agencies' BiOp implementation plans. An initial analysis of the degree to which current or anticipated actions meet the requirements is presented for the purpose of identifying gaps in program/project coverage. Lastly, each section outlines the Workgroup's strategy for addressing these gaps.

(2) RPA 182: Relative Reproductive Success of Hatchery Spawners

(a) Action Item 182 is presented in Section 9.6.5.3.2 of the BiOp, and states

The Action Agencies and the NMFS shall work within regional priorities and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to determine the reproductive success of hatchery fish relative to wild fish. At a minimum, two to four studies shall be conducted in each ESU. The Action Agencies shall work with the Technical Recovery Teams to identify the most appropriate populations or stocks for these studies no later than 2002. Studies will begin no later than 2003.

a. 1) Discussion of RPA 182

Artificial production of anadromous salmonids has occurred on a very large scale for many years in the Columbia River Basin to mitigate for development and support fisheries. More recently, artificial production has been seen as a tool that might be useful to contribute to recovery of depressed populations, particularly those listed under the Endangered Species Act (ESA). One

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[7] Active participants in the Hatchery/Harvest Workgroup are Larry Rutter (NOAA Fisheries; Chair); Jon Drake (NOAA NWFSC); Peter Lofy (BPA), Jeff Gislason (BPA), and John Skidmore (BPA).

result of artificial production, intentional in some cases and inadvertent in others, is that many populations in the Basin are now comprised of a mix of natural-origin and hatchery-origin spawners. This circumstance presents two kinds of problems, one biological and one data-related, which combine to mask the true status of natural populations in the Basin, and is referred to here as the "masking problem." A description of the masking problem is described in McClure et al., 2000:

> One of the greatest uncertainties does not involve the biology of salmonids; it is a simple counting problem. Hatchery fish spawn with wild fish to varying degrees throughout the Columbia River Basin. In some cases we have virtually no rigorously collected samples to indicate what percentage of the wild spawners are from a hatchery. In virtually all cases, even if we knew what fraction of spawners were hatchery fish, we do not know to what extent those hatchery fish are successful at spawning, or even if they were successful at all. The foundation of the most basic population analysis for any fish stock involves counts of spawners and recruits per spawner. When dealing with wild fish that mix with hatchery fish on the spawning ground, ignorance about the **number of hatchery fish** and **their reproductive success** means that estimates of recruits per spawner are compromised. Without **widespread quantitative estimates of hatchery spawning contributions** and more selective estimates of **relative reproductive fitness of hatchery fish**, our analyses (and for that matter anyone's quantitative analyses of salmonid populations) are highly uncertain.... (emphasis added)

The immediate objective of RPA 182 is to ensure that studies are in place in 2003 that would begin to address the issues described above to improve the status assessments called for in the BiOp at the 2005 and 2008 check-ins. As noted above, the masking issue can be broken into two components, each requiring a different response.

The biological aspect of the masking problem stems from peer-reviewed studies indicating that hatchery-origin spawners have lower reproductive success when they spawn in the wild than natural-origin spawners. The causes of the differences in reproductive success of wild-spawning hatchery fish are attributed largely to genetic effects. Uncertainty about parameter estimation required the status assessments contained in the BiOp to rely on a large range (e.g., 20 percent to 80 percent) for the relative reproductive success of wild spawning hatchery fish compared to natural origin fish. This parameter greatly affects conclusions regarding the status of the wild population and the improvement needed to meet ESA survival and recovery criteria. The BiOp calls for tier 3 studies designed to address the critical uncertainty regarding the relative reproductive success of hatchery fish spawning in the wild.

The data-related, or "counting" aspect of the masking problem stems from uncertainty about the numbers of hatchery fish spawning in the wild and their spatial and temporal distribution. Estimates of the numbers of fish spawning in the wild in many cases are based on extrapolations of hatchery and natural-origin fish counts at dams or weirs rather than on field surveys of the spawning grounds. Or, they are based on surveys of spawning ground index areas where the hatchery and natural-origin spawners are not readily distinguishable because the hatchery fish were not marked (a practice that continues to some degree still), or this data simply is not recorded. Where the spatial and temporal distribution of hatchery and natural-origin spawners may differ, errors can be introduced because index data are erroneously expanded to the larger population.

Together with spatial structure and diversity, abundance and population growth rate are key parameters of population viability and extinction risk analysis. The population growth rate, or "lambda," is a predictive estimate of productivity over time, i.e., of how well a population is performing in its environment. To a varying degree, and in some instances, its accuracy depends on the accuracy of counts of natural and hatchery-origin fish in the spawning populations. Unfortunately, for reasons noted above, it sometimes has been difficult or impossible to separately estimate the natural and hatchery-origin components of the spawning populations. As a result, estimates of recruits per spawner for the naturally reproducing component of the population can be inflated.

These uncertainties may affect the degree of improvement needed to achieve ESA survival and recovery objectives for listed populations. Table 9-2-4 of the BiOp provides estimates of the percentage improvement in survival rates needed for each ESU addressed by the RPA to achieve survival and recovery criteria. For the listed Snake River steelhead ESU, this range is from 44 percent to 333 percent. This range is due largely to the masking problem, and explains why the BiOp identifies it as a "critical uncertainty" that must be resolved to enable reliable assessments of population status and better inform recovery planning activities.

(b) Performance Indicators and Standards Relative to RPA 182

The performance standard applicable to this RPA requires resolution of the masking issue, which must address both the biological question regarding the relative reproductive success of hatchery fish spawning in the wild and the related counting question of the extent, spatial, and temporal distribution of hatchery fish spawning in the wild. Resolution of the biological question would lead to a substantial narrowing of the range of relative spawning effectiveness of hatchery fish used in the BiOp (e.g., 20 percent to 80 percent). Assuming the counting question also is resolved with an improved status monitoring program, this would enable better future assessments of the status of listed populations and better inform estimates of the extent of improvement in survival rates necessary to achieve ESA survival and recovery criteria. This information may also prove useful to recovery planning in that it might inform decisions about whether, under what circumstances, and to what extent artificial production may provide a demographic benefit to populations.

For the purpose of implementation of the BiOp, the applicable performance indicator is the initiation and continuance of a sufficient number and quality of studies by the 2003 check-in. The studies must be designed to produce quantitative results usable in life cycle models to facilitate future assessments of the status of the listed ESUs addressed in the RPA.

a. 1) Overview of requirements of RPA 182

As noted previously, the masking problem has two components, dubbed herein as the "counting" component and the "biological" component. Each must be addressed in the RME plan. The text of RPA 182 prescribes two to four studies per ESU, but is non-specific as to what constitutes a "study" in this context.

Counting component. The Workgroup considers this issue to be encompassed in the broader effort to improve status monitoring. A separate RME workgroup has been established specifically to address status monitoring; that group will determine the extent to which additional RME projects may be needed to address this aspect of the masking problem. In addition, because the counting problem stems in part from the inability to distinguish hatchery from natural-origin fish, a comprehensive marking strategy is under development pursuant to RPA 174 to ensure that hatchery and natural-origin fish can be more reliably distinguished in the spawning escapement. Failure to externally mark most or all hatchery production will make answering this question extremely difficult and/or expensive.

Biological component. As noted above, RPA 182 calls for a minimum of two to four studies in each ESU to be underway in 2003, but provides no guidance of what constitutes a "study" in this context. It is not clear, for example, whether a tally of studies would include investigations into the counting component of the masking problem. A robust scientific approach would involve studies focused on more than one population within each multi-population ESU to determine the extent to which reproductive success may vary among populations, as well as to replicate results. For the purpose of determining the minimum level of RME necessary to meet the intent of RPA 182, this plan assumes there must be, at a minimum, one tier 3 study directed at the relative reproductive success of hatchery fish underway in 2003 for each of the listed ESUs addressed by the RPA, other than Snake River sockeye.[8] An RPA 182 study focused on Columbia River chum may not be necessary to address the masking issue, due to the relatively minor amount of artificial production in the past, but could contribute greatly to recovery planning. Existing studies in an ESU, though possibly relevant to the critical question, will not automatically count toward this minimum if they are not designed to provide the kind of quantitative results envisioned by the RPA. However, it may be feasible to modify existing studies to meet requirements of RPA 182.

a. 2) General description of current projects (or expected to be funded) relevant to RPA 182

A number of studies are underway in the basin and elsewhere that will provide information relevant to the relative reproductive success of hatchery fish. While these studies may be useful, many do not provide the kind of specific and quantitative results required to fulfill the purposes of the BiOp. In addition, not all ESUs are addressed by the current studies, and some of the studies are directed at populations not pertinent to the RPA. State-of-the-art, pedigree-based (DNA or chemical progeny marker) research on relative reproductive success of hatchery-origin and natural-origin salmon and steelhead (see Table 182-A) is being conducted on, or has been proposed for, five populations of steelhead, seven populations of spring chinook, two coho populations, and one sockeye populations, as follows.

[8] Given the minimal number of natural-spawning fish in this ESU, and considering that most of those fish are the progeny of artificial production, an RPA 182 study directed at this ESU is considered non-essential.

SPECIES	**ESU**	**POPULATION**	**PROVINCE**
A. Steelhead			
	Olympic Peninsula	Forks Cr.	WA Coast
	Snake STHD	Little Sheep Cr.	Blue Mt.
	MCR STHD	Umatilla	Col. Plateau
	LCR STHD	Abernathy	L. Columbia*
	LCR STHD	Hood	Col. Gorge
B. Spring chinook			
	Snake SSCH	Lostine R.	Blue Mt.
	Snake SSCH	Catherine Cr.	Blue Mt.
	UCR SCH	Wenatchee	Col. Cascade*
	LCR SCH	Kalama	L. Columbia*
	Snake SSCH	Tucannon	Blue Mt.*
	MCR SCH	Yakima	Col. Plateau
C. Coho			
	Puget Sound	Minter Creek	Puget Sound
	L. Col. River	Abernathy	L. Columbia*
D. Sockeye			
	Lake Ozette	Lake Ozette	Wash. Coast

* proposed in Mainstem/Systemwide solicitation

DRAFT! **TABLE RPA 182-A: LIST OF PROJECTS INVESTIGATING RELATIVE REPRODUCTIVE SUCCESS OF HATCHERY FISH** ***DRAFT!***

REF. CODE	PROJECT #	TITLE	PROVINCE SUBBASIN	SPECIES ESU	COMMENTS
182-A	HSRG	Interactions Between Wild and Hatchery Steelhead – Key Assumptions	WA Coast Forks Creek	Olympic Peninsula Steelhead	Use msDNA to reveal origin of juvenile steelhead for relative reproductive success of hat. and nat. fish; interbreeding
182-B	198909600	M&E Genetic Characteristics of Supplemented Salmon and Steelhead	Blue Mt Grande Ronde Imnaha, Tucannon, Salmon, Clearwater	Snake SSCH Snake STHD	MsDNA Pedigree-based research on Little Sheep Cr. Steelhead and Lostine and Catherine Cr. Spr Chinook. Estimate selection gradients.
182-C	35041	Reproductive Success of Hatchery & Natural Spr. Chinook in Wenatchee, Tucannon, and Kalama Rivers	Col. Cascade Blue Mt. Lower Col. Wenatchee Tucannon Kalama	UCR SCH LCR SCH Snake SSCH	MsDNA-based pedigree research on relative reproductive success of naturally spawning hatchery and natural origin fish.

DRAFT! TABLE RPA 182-A: LIST OF PROJECTS INVESTIGATING RELATIVE REPRODUCTIVE SUCCESS OF HATCHERY FISH DRAFT!

REF. CODE	PROJECT #	TITLE	PROVINCE SUBBASIN	SPECIES ESU	COMMENTS
182-I	200204700	Develop Progeny Maker for Salmonids to Evaluate Supplementation	Col. Plateau Umatilla	MCR STHD	Develop and test chemical progeny marker. Apply to female steelhead to test relative reproductive success of hatchery-origin fish
182-N	HSRG	Differences in Natural Production Between Hatchery and Wild Coho – Influence of Hatchery Ancestry	Puget Sound Minter Cr.	Puget Sound Coho	Use msDNA to evaluate reproductive competence between hatchery and wild coho.
182-O	35027	Evaluation of Two Captive Rearing Methods for Assisting Recovery of Naturally Spawning Steelhead and Coho	Lower Col. R Abernathy Cr.	LCR STHD LCR Coho	Evaluate captive rearing of steelhead and coho and then relative reproductive success of HOR v. NOR
182-R	199506325	Yakima/Klickitat Project M&E	Col. Plateau Yakima	Spr. Chinook	Evaluate reproductive success of HOR and NOR spring Chinook
182-W	199005200	Performance/Stock Productivity Impacts of Hatchery Supplementation	Mt. Snake Clearwater	Snake STHD	Evaluate HxH, HxW, WxW in streams and hatchery. Survival in migration and to adult
182-D-G	198909800 198909801 198909802 198909803	Idaho Supplementation Studies	Mt. Snake Clearwater Salmon	Snake SSCH	Evaluate 31 streams of supplemented versus control populations. Measures survival, genetic structure, individual and population parameters
182-H	199005500	Idaho Supplementation Studies – Steelhead	Mt Snake Clearwater Salmon	Snake STHD	Evaluate steelhead supplementation. Genetic database on 72 wild and 5 hatchery stocks. Measure abundance, trends, genetic attributes
184-R	HSRG	Genetic Characterization of Lake Ozette Sockeye	WA Coast Ozette	Ozette SOCK	Use otolith marking and genetic data to monitor HOR and NOR abundance and interactions
184-DD	200001900	Tucannon Spr. Chinook Captive Broodstock Rearing and Research	Col. Plateau Tucannon	Snake SSCH	Uses genetic data to determine source of returning spawners
182-U	198805304	Hood River Production Program M&E	Col. Gorge Hood	LCR STHD	Use msDNA analysis on archived steelhead scales from 1991 on
182-X	OWEB	Non-Parieal Pedigree Project	OR Coast Umpqua	OR Coastal Coho	Use msDNA on HOR and NOR coho. Status uncertain

a. 3) GAP assessment: what more is needed

Given its survey of existing and proposed (and likely to be funded) studies, the Workgroup has identified certain gaps in existing research relative to minimal BiOp needs for RPA 182. Additional studies designed to produce quantitative results on the relative reproductive success of hatchery fish spawning in the wild are needed for the following ESUs or populations: Upper Columbia steelhead ESU, Mid-Columbia River steelhead ESU; an ocean-type chinook ESU (either directly involving the Snake River fall chinook ESU or a suitable representative population of ocean type fall chinook), and Columbia River chum ESU, the latter primarily to better inform the development of recovery options.

(c) Action plan for meeting RME needs for RPA 182

c. 1) Guidelines for RPA 182 RME projects

The fundamental biological question encompassed in RPA 182 requires that any differences in reproductive success of hatchery and wild fish spawning naturally in the same population be quantified. (As noted previously, the counting question will be addressed elsewhere.) Therefore, RPA 182 studies must be designed to directly measure these differences. Parentage analysis using molecular genetic techniques is likely to be the most robust method to measure reproductive success, but other methods will be considered if they address the questions of interest in a sufficiently thorough manner. The development of promising new methods, such as chemical progeny markers, also should be pursued. Reproductive success needs to be evaluated in terms of the ability of wild-spawning hatchery fish to produce progeny that complete the entire life cycle, i.e., to produce F2 spawners. The pertinent question is:

- Do hatchery-origin fish reproduce in the wild less successfully than natural-origin fish and, if so, what is the extent of this difference, measured in terms of F2 productivity?

The lower reproductive success of hatchery-origin spawners may well be a function of several mechanisms, such as reduced genetic fitness, behavioral deficiencies, hatchery domestication, intentional and unintentional selection during hatchery broodstock collection, and the accumulation and maintenance of deleterious alleles in the hatchery population. Some hatchery practices have been reformed in recent years in attempts to reduce deleterious effects and/or improve the potential for positive contributions of hatcheries. Many reforms have been in place for only a few years, and the putative benefits have not been empirically demonstrated with peer reviewed scientific studies. Nevertheless, it is probable that at least some widely implemented reforms have reduced deleterious effects, improved hatchery fish performance, and/or conferred demographic benefits on natural populations. For the purpose of providing the most relevant information for RPA 182, studies directed at populations affected by "reformed" hatchery practices are preferred; it will be of less value, for example, to study the relative reproductive success of wild-spawning hatchery fish produced using out-of-basin stocks.

c. 2) Plans for addressing gaps in RPA 182.

As a result of the gap analysis described in section a.3, above, the need has been identified for additional studies directed specifically at certain ESUs. To obtain these studies, the Workgroup has prepared a Request for Proposals describing the needed studies. The FCRPS Action Agencies have committed to issuing a targeted solicitation in early 2003, with the objective that suitable projects can be identified and initiated in 2003.

(3) RPA 184: Effectiveness of Hatchery Reforms and Conservation Hatcheries

(a) Action Item 184 is presented in Section 9.6.5.3.4 of the BiOp, and states:

The Action Agencies and the NMFS shall work within regional priorities and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a hatchery research, monitoring, and evaluation program consisting of studies to determine whether hatchery reforms reduce the risk of extinction for Columbia River basin salmonids and whether conservation hatcheries contribute to recovery.

a. 1) Discussion of RPA 184

As noted previously, artificial production of salmonids occurs on a very large scale in the Columbia River Basin to mitigate for development and support fisheries, and is also seen today as a potential tool to help recover species listed under the ESA. Artificial propagation activities can impart deleterious genetic, ecological, or management effects on natural populations. In recent years many reforms have been emplaced or proposed that are designed to reduce these deleterious effects and/or improve the performance of hatchery fish used in conservation programs, thereby contributing to the recovery effort. The hypothesis is that deleterious effects of artificial production on listed populations can be reduced, thereby contributing to a reduction in extinction risk for affected natural populations. For conservation activities, the hypothesis is that properly designed intervention with artificial production, under certain circulstances, can make a net positive contribution to recovery of listed populations.

As noted in the BiOp, the fundamental premise underlying hatchery reforms is that artificial production programs can be operated consistent with, and complementary to the goals of the ESA while still achieving their fishery mitigation objectives (BiOp at 9-152). A list of artificial production reforms designed to reduce ecological, genetic, and/or management risks to listed species, and/or to improve the performance of hatchery fish, is identified in section 9.6.4.2 of the FCRPS BiOp. Many of the reforms encompassed in this list already have been implemented in recent years for some hatchery programs. Unfortunately, many reforms flow from hypotheses that are difficult to test with limited empirical data. A comprehensive RME approach is needed for evaluating hatchery reforms, particularly in terms of their ultimate efficacy in reducing extinction risk of listed species and contributing to recovery.

For the purpose of implementing RPA 184, two separate but related topics are considered here: the efficacy of hatchery reforms in reducing extinction risk, and of conservation hatcheries in contributing to recovery.

Efficacy of hatchery reforms in reducing extinction risk. Many hatchery reforms are designed to reduce the deleterious ecological, genetic, or management effects of artificial production on listed ESUs using a variety of approaches. For example, to minimize deleterious genetic effects, acclimation ponds are constructed and used to manage unwanted straying and/or increase homing fidelity of hatchery fish, inappropriate brood stocks are replaced and/or hatchery brood stocks are more routinely infused with fish from locally adapted populations. Rearing and release strategies designed to minimize ecological interactions of hatchery juveniles with natural origin fish (e.g., predation, competition) are utilized. Reforms designed to improve survival of hatchery fish produced for fishery mitigation purposes could result in the need to produce less of them to achieve fishery objectives, thereby reducing costs and, potentially the extent of unwanted ecological interaction with juvenile listed fish. The challenge in evaluating reforms lies in isolating the effect of the reform in a controlled study and quantifying it in terms of effect on population viability.

Efficacy of conservation hatchery activities in contributing to recovery. Conservation hatchery activities, as loosely defined herein, can take many forms, some of which are touted even in the absence of scientific justification. They include many (but not all) supplementation and reintroduction programs (egg, fry/fingerling, smolt, or adult plants), captive brood and captive rearing strategies, steelhead kelt reconditioning, and similar types of activities distinguished, as a group, by their focus primarily on conservation and recovery rather than fishery objectives (at least in the near term). Conservation may be the sole purpose of a particular hatchery facility, or it may be one of several activities conducted at a particular facility. This aspect of RPA 184 seeks to determine the efficacy of these conservation hatchery activities, i.e., the extent to which they provide a net positive effect on survival of listed species, thereby contributing to recovery. Positive effects may result from any number of mechanisms. For example, reforms may seek to improve the survival of hatchery fish that are used to provide a demographic boost to a listed population while not undermining its genetic diversity. Or, they may be designed to enable a facility to produce multiple, separate lots of fish for supplementation of specific tributaries thereby reducing the homogenization effect of supplementation.

Performance Standards Relative to RPA 184

RPA 184 prescribes RME activities directed at determining the effectiveness of hatchery reforms at reducing extinction risk and conservation hatchery activities at contributing to recovery. This RPA is part of a class of RME items referred to in the BiOp as action effectiveness research (AER). Because the subject matter involved in this RPA is hatchery reform and conservation hatchery activities which strive to accomplish certain substantive results consistent with performance standards applicable to hatchery programs, it is easy to confuse those desired results with the performance standards applicable to this RPA item. The subject matter here involves performance standards applicable to effectiveness research rather than to hatchery programs and activities. Thus, the applicable performance standard here relates to the ability of the study or studies to detect changes in survival resulting from reforms or conservation hatchery activities. Detecting survival changes at the level of individual fish or a production lot may be relatively straightforward; detecting it at the population or the ESU level can be daunting. At these levels, it may be necessary to evaluate the effect of groups of reforms in order to achieve the necessary statistical power to adequately test hypotheses involving hatchery reforms and conservation hatchery activities.

A more thorough discussion of performance standards and indicators relevant to AER studies is provided in the AER section of this RME plan. Though focused particularly on the effectiveness of habitat actions, that section is also relevant to effectiveness research prescribed by this RPA. Like habitat effectiveness studies, hatchery reforms and conservation hatchery activities are management actions, meaning they are purposeful manipulations of the environment. As such, effectiveness studies should be viewed as experiments that should be conducted consistent with good scientific research methods, including clearly stated hypothesis, controlled experimentation, replication, and peer review.

b. 1) Overview of requirements of RPA 184

RPA 184 requires an unspecified number of studies designed to determine the efficacy of hatchery reforms in reducing extinction risk and whether conservation hatchery activities contribute to recovery. No specific schedule is provided for initiating or completing such studies, but the BiOp requires that priority studies be undertaken by the 3-year check-in (BiOp Appendix F). Thus, to determine adequacy of RPA 184 efforts relative to BiOp needs, the Workgroup considered the underlying intent of this RPA to determine whether sufficient RME is underway to address that intent with sufficient scope and in a meaningful timeframe.

On this basis, the Workgroup interprets RPA 184 as requiring studies focused particularly on the efficacy of problematic reforms and conservation activities that are being proposed for implementation in many hatchery programs and/or are likely to be proposed in connection with the basinwide HGMP process established pursuant to RPA 169. Of less immediate interest are studies that focus on evaluating the efficacy of programmatic reforms (e.g., clarification of a hatchery's goals and objectives) or generally agreed operational reforms (e.g., phasing out of non-local brood stocks). The rationale for this approach is that priority should be afforded to studies of those reforms or conservation hatchery activities that are most likely to be advocated by regional interests on the basis of their assumed (rather than proven) beneficial effects.

b. 2) General description of current projects underway relevant to RPA 184

A large number of hatchery reforms and conservation hatchery activities involving many facilities and populations currently are being evaluated across the basin. Many will provide results very pertinent to RPA 184, but many of those will require modification and/or additional analysis to address the specific questions identified in the RPA. For example, studies exist which consider the effect of a particular reformed hatchery practice on the fish produced in the hatchery or on other populations affected by the hatchery fish, but these effects are seldom evaluated in terms of extinction risk for an ESU. Some conservation activities, such as supplementation programs, are evaluated for their effectiveness in returning F1 spawners, but fewer focus on F2 spawners or the other questions pertinent to the recovery of viable populations, such as genetic diversity and population structure.

As a first step in evaluating the sufficiency of current activities applicable to RPA 184 and to facilitate the identification of gaps in existing research relative to BiOp needs, the Workgroup compiled a list of potentially relevant projects underway or likely to be funded. For research directed at reforms intended to reduce extinction risk, the nature of the effects being evaluated was identified, e.g., genetic, ecological interaction, or management effects (Table 184-1, below). For conservation activities, the type of activity and life stage involved was identified (e.g., supplementation approach) and summarized in Table 184-2. These lists were compared to a research priority scheme based on the likely effects of actions on the status of natural populations (Table 184-3), and from this comparison a very preliminary list of priority research needs was identified (section b.3, below).

PRELIMINARY DRAFT TABLE RPA 184-1: STUDIES OF HATCHERY REFORMS TO REDUCE THE RISK OF EXTINCTION						
TYPE OF REFORM	**REF. CODE**	**PROJECT #**	**TITLE**	**PROVINCE/ SUBBASIN**	**SPECIES/ ESU**	**COMMENT**
Ecological	184-A	HSRG	Development of Methods on Effects of Hatchery Release Methods on Residualism and Interactions in Relation to Stream Carrying Capacity			Competition for food and space. Methods development.
Ecological	184-B	HSRG	Development of BKD Vaccine			Disease transmission. Control incidence in hatchery and environment
Ecological	184-C	HSRG	Residualism in Wild Broodstock Steelhead	Lower Col. River Kalama	LCR STHD	Residualism. Assess factors; develop methods to reduce.
Ecological	184-F	35039	Influence of Hatcheries on Health and Physiology of Naturally Rearing Fish	Col. Gorge Big White Salmon	Spr Chinook Steelhead	Disease transmission. Effects of hatcheries on BKD in environment and health of natural fish.
Ecological Genetic	184-G	199105500	Natural Rearing Enhancement Systems – NATURES	Systemwide	Chinook, coho, sockeye, steelhead	Domestication. Competition and Survival. Evaluate natural-like culture facilities and method
Ecological Genetic	184-P	200203800	Physiological Assessment of Wild and Hatchery Juvenile Salmonids	Col. Plateau Yakima	MCR SCH	Domestication Competition and Survival. Evaluate natural-like culture facilities and method
Ecological	184-H	199901800	Characterize and Quantify Residual Steelhead in the Clearwater	Mt. Snake Clearwater	Snake STHD	Residualism. Quantify interactions with wild steelhead. Assess rearing practices
Ecological	184-J	199801004	M&E Snake Fall Chinook Released above Lower Granite	Blue Mt.	Snake FCH	Competition. Evaluate post-release behavior
Ecological	184-M	35063	Compare Bacterial Fish Pathogen Populations in Hatchery and Adjacent Creek, Evaluate Disease Transfer	Lower Col. River Abernathy	LCR Coho LCR STHD Cutthroat	Disease Transmission. Determine two bacterial pathogens in hatchery and creek; examine fish for diseases
Ecological	184-N	200101	LSRCP-Dworshak Spring Chinook	Mt. Snake Clearwater	Spr. Chinook	Disease Transmission. Evaluate erythromycin for FDA registration to reduce BKD incidence

PRELIMINARY DRAFT TABLE RPA 184-1: STUDIES OF HATCHERY REFORMS TO REDUCE THE RISK OF EXTINCTION						
TYPE OF REFORM	**REF. CODE**	**PROJECT #**	**TITLE**	**PROVINCE/ SUBBASIN**	**SPECIES/ ESU**	**COMMENT**
Genetic	184-D	HSRG	Olfactory Imprinting in Hatchery Salmon	Puget Sound	Puget Sound Coho	Outbreeding depression. Develop molecular and electrophysiological assessment tools for homing – reduce straying
Genetic	184-E	35012	Spatial Scales of Homing and Efficacy of Hatchery Supplementation of Wild Pops.	Col. Plateau Yakima	MCR SCH	Outbreeding depression. Examine patterns of imprinting, homing, spawning per acclimation.
Genetic	184-I	199801003	Spawning Distribution of Snake Fall Chinook	Blue Mt. Hells Canyon	Snake FCH	Outbreeding depression. Determine homing with acclimation facilities
Genetic Ecological	184-K	199805303	Hood River Production M&E	Col. Gorge Hood	MCR SCH LCR STHD	Outbreeding depression. Domestication. Evaluate supplementation effects on natural pops.
Genetic Ecological	184-L	199805304	Hood River Production M&E	Col. Gorge Hood	MCR SCH	Outbreeding depression. Domestication. Evaluate supplementation effects on natural pops.
Genetic	184-O	199005200	Performance/Stock Productivity Impacts of Supplementation	Mt. Snake Col. Plateau Clearwater Deschutes	Snake STHD MCR SCH	Domestication. Evaluates hatchery practices on growth and survival of steelhead and Chinook.
Genetic	184-S	HSRG	White River Acclimation Pond Evaluation	Puget Sound White River	Puget Sound Coho	Outbreeding depression. Evaluates spawning distribution of acclimated fish
Management	184-Z	200001700	Kelt Reconditioning-Enhance Iteroparity in Col. Steelhead	Col. Plateau Yakima	MCR STHD	Broodstock collection. Reduce effects of broodstock collection on population.
Management	184-WW	29007	Okanogan Kelt Reconditioning	Col. Cascade Okanogan	UCR STHD	Broodstock collection. Reduce effects of broodstock collection on population.

TABLE RPA 184-2: STUDIES OF THE EFFECTIVENESS OF CONSERVATION HATCHERIES						
TYPE OF CONSERVA-TION ACTION	**REF. CODE**	**PROJECT #**	**KEY WORDS OR TITLE**	**PROVINCE & SUBBASIN**	**SPECIES ESU**	**COMMENTS**
Supplementation	184-R	HSRG	Genetic Characterization of Lake Ozette Sockeye	Wash. Coast Ozette	Lake Ozette Sockeye	Fingerling plant
Supplementation	184-S	HSRG	White River Acclimation Pond Evaluation	Puget Sound White River	Spring Chinook	Smolt plant
Supplementation	184-T	HSRG	Snow Creek Coho Recovery	Puget Sound Snow Creek	Puget Sound Coho	Egg plant Fingerling plant
Supplementation	184-U	HSRG	Hamma Hamma Steelhead Evaluation	Puget Sound Hamma Hamma	Puget Sound Steelhead	Smolt plant
Supplementation Altered Stream	184-V	HSRG	Development of Engineered Streams	Puget Sound Dungeness	Puget Sound Coho	Egg plant
Supplementation NATURES	184-W	HSRG	Rearing Coho with NATURES Raceways	Puget Sound Several hat.	Puget Sound Coho	Control v. test raceways
Supplementation NATURES	184-X	HSRG	Semi-natural Habitat to Increase Chinook Survival	Puget Sound Nisqually	Puget Sound Chinook	Test structures added to rearing pond on survival
Supplementation	184-EE	199000500	Umatilla Hatchery M&E	Col. Plateau Umatilla	MCR STHD	Assess survival and contribution to natural pop.
Supplementation Captive Brood	184-FF	199800702	Grande Ronde Supplementation – Lostine	Blue Mt. Grande Ronde	Snake SSCH	Suppl. and captive smolts
Supplementation Captive Brood	184-GG	199800703	Grande Ronde Supplementation M&E	Blue Mt. Grande Ronde	Snake SSCH Snake STHD	Suppl. and captive smolts
Supplementation	184-JJ	199805301	Grande Ronde/Imnaha Spr, Chinook Supplementation	Blue Mt. G.R./Imnaha	Snake SSCH	Plan, implement, and M&E recovery-smolt
Supplementation	184-KK	200105300	Lower Col. River Chum in Duncan Creek	Lower Col. Duncan Cr.	Col. River Chum	Fry plant
Supplementation	184-LL	200107	LSRCP-NPT Evaluation	Blue Mt G.R./Imnaha	Snake SSCH Snake STHD	Smolt plant. Survival of hat. and nat. fish
Supplementation	184-MM	200108	LSRCP – NPT Evaluations	Mt. Snake Salmon	Snake SSCH	Smolt plant. Spawner composition Genetic analysis. Contribution of hatchery origin adults

TABLE RPA 184-2: STUDIES OF THE EFFECTIVENESS OF CONSERVATION HATCHERIES						
TYPE OF CONSERVA-TION ACTION	**REF. CODE**	**PROJECT #**	**KEY WORDS OR TITLE**	**PROVINCE & SUBBASIN**	**SPECIES ESU**	**COMMENTS**
Supplementation	184-NN	200109	LSRCP – ODFW Evaluations	Blue Mt. G.R./Imnaha	Snake SSCH Snake STHD	Smolt plant. Survival of hat-origin fish
Supplementation	184-OO	200117	LSRCP-Grande Ronde Steelhead and Fall Chinook Evaluation	Blue Mt. G.R./Snake	Snake STHD	Smolt plant. Survival, genetics, distribution
Supplementation	184-PP	200118	LSRCP-Evaluation of Salmonids	Blue Mt. Hells Canyon	Snake FCH	Fingerlings. survival, genetics, life-history
Supplementation	184-QQ	200116	LSRCP-M&E Asotin Creek	Blue Mt. Asotin	Snake SSCH Snake STHD	Smolt plant. Survival, genetics, distribution of hat. and nat fish.
Supplementation NATURES	184-RR	200119	LSRCP-Hatchery M&E - Idaho	Mt. Snake Salmon	Snake SSCH Snake STHD	Smolt plant. Survival of hat. and nat. Life-history. NATURES
Supplementation Captive Brood	184-SS	200120	LSRCP-Reintroduction of Spr. Chinook and Study Steelhead in Lookingglass Cr. - proposed	Blue Mt. Grande Ronde	Snake SSCH Snake STHD	Smolt plant. Survival of hat. and nat. fish. Genetics
Supplementation	184-TT	200121	LSRCP-Evaluation of Salmonids	Col. Plateau Snake River	Snake FCH	Fingerling plant. Survival, genetics, distribution
Supplementation	184-UU	200122	LSRCP-Walla Walla Steelhead Evaluation	Col. Plateau Walla Walla	MCR STHD	Smolt plant. Survival of hat. and nat. Genetics
Supplementation	184-VV	200123	LSRCP-Tucannon Spr. Chinook and Steelhead Evaluation	Co. Plateau Tucannon	Snake SSCH Snake STHD	Smolt plant. Survival of nat. and hat. Genetics, Life-Hist.
Supplementation	184-XX	199701500	Imnaha River Smolt Monitoring	Blue Mt. Imnaha	Snake STHD	Smolt plant. Survival of hat. and nat fish thru dams
Supplementation	184-YY	198902401	Juvenile Salmonid Outmigration in Lower Umatilla River	Col. Plateau Umatilla	MCR STHD	Smolt plant. Survival of hat. and nat. fish

TABLE RPA 184-2: STUDIES OF THE EFFECTIVENESS OF CONSERVATION HATCHERIES						
TYPE OF CONSERVA-TION ACTION	**REF. CODE**	**PROJECT #**	**KEY WORDS OR TITLE**	**PROVINCE & SUBBASIN**	**SPECIES ESU**	**COMMENTS**
Supplementation	182-D	198909800	Idaho Supplementation Studies	Mt. Snake Salmon, Clearwater	Snake SSCH	Smolt plants. 31 streams evaluated; test v. control streams
Supplementation	182-E	198909801	Idaho Supplementation Studies	Mt Snake Clearwater	Snake SSCH	Smolt plants. Data collected on 2 tribs.
Supplementation	182-F	198909802	Idaho Supplementation Studies	Mt Snake Salmon, Clearwater	Snake SSCH	Smolt plants. Data collected in 9 tribs.
Supplementation	182-G	198909803	Idaho Supplementation Studies	Mt Snake Salmon	Snake SSCH	Smolt plants. Data collection in 6 tribs.
Supplementation	182-H	199005500	Idaho Supplementation Studies - Steelhead	Mt. Snake Salmon, Clearwater	Snake STHD	Gathering info on wild steelhead pops. Genetic data on 72 wild and 5 hat pops
Captive Broodstock	184-Y	199305600	Assess Captive Broodstock Technologies	Mt. Snake Salmon	Snake SOCK Snake SSCH	Develops and improves tech.
Captive Brood Supplementation	184-FF	199800702	Grande Ronde Supplementation – Lostine	Blue Mt. Grande Ronde	Snake SSCH	Suppl. And captive smolts
Captive Brood Supplementation	184-GG	199800703	Grande Ronde Supplementation M&E	Blue Mt. Grande Ronde	Snake SSCH Snake STHD	Suppl. and captive smolts
Captive Brood	184-AA	199107200	Redfish Lake Sockeye Captive Broodstock Program	Mt. Snake Salmon	Snake SOC	Evaluate survival of various strategies
Captive Brood	184-BB	199204000	Redfish Lake Sockeye Captive Broodstock Rearing and Research	Mt. Snake Salmon	Snake SOC	Evaluate captive brood propagation
Captive Brood	184-DD	200001900	Tucannon Spr. Chinook Captive Broodstock Program	Col. Plateau Tucannon	Snake SSCH	Survival, Genetics, Evaluate propagation
Captive Brood	184-HH	199801001	Grande Ronde Spr, Chinook Captive Broodstock Program	Blue Mt. Grande Ronde	Snake SSCH	Evaluate G.R., Lostine, Catherine populations
Captive Brood	184-II	199801006	Captive Broodstock Artificial Propagation	Blue Mt. Grande Ronde	Snake SSCH	Evaluate rearing regimes

TABLE RPA 184-2: STUDIES OF THE EFFECTIVENESS OF CONSERVATION HATCHERIES						
TYPE OF CONSERVA-TION ACTION	**REF. CODE**	**PROJECT #**	**KEY WORDS OR TITLE**	**PROVINCE & SUBBASIN**	**SPECIES ESU**	**COMMENTS**
Captive Rearing	184-CC	199700100	Idaho Chinook Captive Rearing Program	Mt. Snake Salmon	Snake SSCH	Adult plants. Develop and test propagation and field performance
Captive Rearing	182-O	35027	Evaluate 2 Captive Rearing Methods for Steelhead & Coho	Lower Col. R. Abernathy Cr.	LCR STHD LCR Coho	Steelhead adult plants Coho smolt plants
Kelt Recondition	184-Z	200001700	Kelt Reconditioning – Enhance Iteroparity in Columbia Steelhead	Col. Plateau Yakima	MCR STHD	Adult plants. Develop and test propagation. Evaluate field performance; options
Kelt Recondition	184-WW	29007	Okanogan Kelt Reconditioning	Col. Cascade Okanogan	UCR STHD	Adult plants. Develop and test propagation. Evaluate field performance

b. 3) Gap assessment: what more is needed

Based on its assessment of ongoing research relative to BiOp needs, the Workgroup concluded that sufficient studies directed at the effectiveness of conservation hatchery activities are underway. However, several issues were identified as gaps relating to the effectiveness of hatchery reforms in reducing extinction risk. They fall into two categories, the first being more urgent than the second:

Category 1 (most urgent, i.e., needed for 2003 check-in):

- Benefit/risk of steelhead kelt reconditioning, including evaluation of the relative reproductive success of steelhead kelts, as compared to standard broodstock collection and smolt supplementation techniques, with particular focus on effects on small natural steelhead populations.

- Methodologies or analytical models (e.g., growth rate and extinction risk models) for synthesizing the results and detecting the effects at the population and ESU levels of a myriad of hatchery reforms and conservation hatchery activities in terms of their effects on extinction risk and/or recovery. As noted previously, most studies of hatchery reforms necessarily will focus on effects on individual lots of fish at a particular life stage. Therefore, the degree to which a reform reduces extinction risk at the population or ESU level will have to rely on models developed outside the particular study and/or as-yet unavailable information relating populations to ESUs. Similarly, many conservation hatchery activities will rely on imputed effects on recovery, i.e., on analysis of the contribution of the conservation hatchery to a particular life stage and, in turn, on effects at the population and ESU levels. (There will be cases, however, where measurement of the effects of conservation hatchery activities can encompass the entire life cycle for a group of fish.) This reliance on models and analyses extraneous to specific studies to detect changes in extinction risk or recovery will have to be taken into account in the design and selection of RPA 184 effectiveness studies and in applying any conclusions reached. Because no methodology currently exists for this kind of analyses, effective compliance with the intent of RPA 184 requires the development of suitable methodologies for synthesizing the results of reforms and conservation activities.

Category 2

- Predation by steelhead smolts on emerging steelhead, chum, or chinook fry

- Predation by spring chinook smolts on emerging steelhead, chum, or chinook fry

- Short-term (but perhaps intensive) competition for food and space between hatchery releases of steelhead smolts and chinook smolts and fingerlings and natural-origin fish in the tributary spawning and rearing habitat.

(b) Action plan for meeting RME needs for RPA 184

b. 1) Guidelines for RPA 184 projects

The purpose of RPA 184 is to determine the efficacy of hatchery reforms in reducing extinction risk and of conservation hatchery activities in contributing to recovery. This puts this RPA in the category of Tier 3 action effectiveness research, guidelines for which are generally described in Section 9.5.6.3 of the FCRPS BiOp, and more specifically in the AER section of this plan.

Generally, these studies should involve controlled scientific experiments designed and replicated sufficiently to provide statistically and biologically meaningful results pertinent, preferably, to multiple programs. For studies of specific reforms, efficacy must be evaluated in terms of the specific fish affected by the study, and, ultimately, in terms of their effects on extinction risk and/or recovery. In some cases, particular hatchery reforms or conservation hatchery activities already have been implemented, and the question is whether extinction risk was actually reduced or whether the action contributed to recovery. The potential may exist that useful information could be derived *post hoc* from actions taken in one area to inform reforms in other areas, assuming the reforms were accompanied by pertinent M&E. Whether studies are designed as new, controlled experiments to provide new information, or information is derived *post hoc,* from previously implemented actions, the overriding objective is to determine the efficacy of reforms in reducing extinction risk for the affected populations and ESUs, or the efficacy of conservation hatchery activities in contributing to recovery under a given set of circumstances.

RPA 184 studies should outline the method employed to isolate and estimate the effects of a particular hatchery reform or conservation hatchery activity on survival, and how it is proposed that these effects will be extrapolated to extinction risk and/or recovery of the affected listed populations or ESUs. The focus should be on the effect of reforms and programs as they are actually conducted in the Basin, rather than on discontinued practices. Most listed salmonids ESUs are comprised of multiple populations, making direct measures of effect on extinction risk or recovery difficult. It therefore will be likely to utilize certain indicators (e.g., survival rates for particular life stages) coupled with life-cycle models or new methodologies to estimate the effect on population growth rates (lambda or other appropriate population parameter), and thereby to evaluate effects of reforms on extinction risk (see sections 1.3.1.2.1 and 1.3.1.2.2 of the BiOp for further guidance). Proposals should clearly identify which measures are employed.

Studies involving hatchery reforms must be designed to address, at a minimum, the following questions:

- What is the nature of the hatchery program's deleterious effects or its potentially positive effects on listed populations?
- What is the efficacy of the hatchery reform in reducing deleterious effects or increasing potentially positive effects?
- To what extent, and with what certainty will reducing deleterious effects or increasing potentially positive effects reduce extinction risk for affected populations, and how is this determined?
- What effect will the reform have on other objectives, such as mitigation or harvest?

Studies involving conservation hatchery activities must be designed to address, at a minimum, the following questions:

- By what mechanism does the conservation hatchery activity being evaluated seek to contribute to recovery? (Best expressed in terms of the four population viability criteria of abundance, productivity, distribution/population structure, and genetic/life-history diversity.)
- What indicators will be evaluated to determine efficacy?
- How will net effect on recovery be evaluated (e.g., by direct measure of survival changes, extrapolation, modeling)?

b. 2) Plans for addressing gaps in RPA 184

As a preliminary result of the gap analysis described above, the need has been identified for additional studies directed at specific topics pertinent to this RPA item. Two topics (noted previously) are most urgent, i.e., projects to address them should be initiated in 2003; the others will be solicited in the next round of Provincial Reviews. To obtain the most urgent of the new studies, the Workgroup has prepared a draft Request for Proposals, which will be issued soon by the Action Agencies.

RPA 167: Improving Estimates of Incidental Mortalities in Fisheries

(c) Action Item 167 is presented in Section 9.6.3.2.2 of the BiOp, and states:

The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop improved methods for estimating incidental mortalities in fisheries, with particular emphasis on selective fisheries in the Columbia River basin, doing so within the time frame necessary to make new marking and selective fishery regimes feasible.

c. 1) Discussion of RPA 167

A major biological issue pertinent to managing fisheries is the extent of incidental mortality imparted on other species or runs. Incidental mortality estimation is particularly critical to the development and implementation of new types of selective fisheries necessitated by the presence of listed species in nearly all major fisheries in the Columbia Basin. For catch and release fisheries, accurate estimates of mortality rates of non-targeted fish are difficult to obtain, yet are essential to determining whether a particular gear or method is suitable for its intended purpose, i.e., in catching the target species while limiting impacts on listed fish. Many variables impact these mortality rates, including encounter rates, gear type, handling techniques, temperature, and recapture rates. Though gear development studies pertinent to the Columbia basin and elsewhere typically focus on immediate and short-term mortality, the critical question relates to effect on ultimate spawning (reproductive) success.

The purpose of RPA 167, therefore, is to improve estimates of incidental mortality rates (in terms of impact on spawning success) for existing fisheries and to determine or verify rates in new or experimental fisheries utilizing new kinds of selective gear and/or methods. The Action Agencies are required to have initiated studies and/or developed methods by the 3-year check-in.

c. 2) Implementation Plan Strategies

RPA 167 is addressed by the Action Agencies in their Implementation Plan for the Federal Columbia River Power System under Harvest Substrategy 1.2: Research to address incidental mortality in selective fisheries. That plan identifies incidental mortality studies underway in the Lower Columbia River in experimental tooth-tangle net fisheries, and “ghost net” recovery efforts in Zone 6 that might lead to estimates of incidental mortalities from that source (and, ultimately, to reducing these mortalities if they are found to be significant and location/removal proves feasible).

(d) Performance Indicators and Standards

Performance standards for allowable incidental mortality of listed fish in fisheries are set by NMFS. The performance standard relevant to this RPA is the estimation of incidental mortality levels in particular fisheries, expressed in terms of effect on spawning reproductive success, using scientific studies capable of providing sufficiently accurate and precise estimates as needed to make fishery management decisions in the context of listed fish.

For the purpose of implementation of the FCRPS BiOp, the applicable performance indicator is the initiation and continuance of a sufficient number and quality of studies by the 2003 check in. The studies must be designed to produce quantitative results applicable to cohort and harvest models used in harvest management. In addition, accurate estimates of both direct and indirect harvest mortality are needed in other forums addressing adult passage survival performance and stock-status monitoring.

(e) RME needs assessment

e. 1) General description of BiOp requirements

RPA 167 does not identify a specific number or type of studies. Rather, it identifies the need to address uncertainties surrounding incidental mortality rates generally, while highlighting the question for fisheries involving new selective gear or methods, particularly those under development per the closely-related RPA 164 (Development of Selective Fishing Methods and Gear).

e. 2) General description of current projects underway relevant to RPA 167

In 2003, the Action Agencies will enter their third year of providing funding to test the feasibility of tooth-tangle nets applied in commercial fisheries for chinook in the Lower Columbia River. These tests are intended to estimate the extent of incidental mortality in these fisheries, thereby to determine whether the commercial gill net fishery using this gear and method can target abundant hatchery fish while constraining incidental impacts on listed fish within established ESA limits. These tests have been refocused in light of results to date, particularly the high numbers of steelhead caught and released during 2002 fishery.

e. 3) GAP assessment

Incidental mortality studies have been undertaken for the selective fisheries currently being evaluated in the Basin. Thus, no specific gap has been identified at this time. This conclusion is premised on continued funding of the incidental mortality studies associated with existing selective fishery evaluations and for any additional selective fishery proposals that may emerge.

Action Plans for meeting RME Needs for 167

In addition to continuation of existing studies, additional incidental mortality studies should be undertaken coincident with the development of any new selective fishery methods or gear prior to widespread deployment. Greater harvest selectivity will provide the greatest survival benefit to listed species if and when it is brought to fisheries with large impact on listed species. Accordingly, the approach to implementation of new RPA 167 studies would be to act opportunistically to new selective fishery proposals as they emerge, and to promote such studies through the co-managers, particularly for high-impact fisheries like the Zone 6 gill net fishery or selective mark recreational fisheries, including steelhead.

F. Appendix F: Data Management Workgroup Plan

(1) Introduction

The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) completed Federal Columbia River Power System (FCRPS) Biological Opinions in December 2000. The NMFS Opinion has specific research, monitoring and evaluation requirements to support periodic assessments of the adequacy of implementation of reasonable and prudent alternatives (RPAs) in the NMFS Opinion. The Federal Action Agencies have completed an Implementation Plan (IP) for the Opinion. The Plan includes a research, monitoring, and evaluation (RME) section.

In early 2002 the Action Agencies established a research, monitoring, and evaluation workgroup to develop an implementation plan for the RPA Actions 179-199 in the NMFS Opinion, and for the USFWS Opinions. The workgroup is comprised of a series of technical subgroups with oversight by a technical/policy group. The RME technical working groups include: Status/Effectiveness, Hydro, Hatchery, Estuary/Ocean and Data Management.[9]

Data management in the Implementation Plan is a subset of the overall information needs for the Opinion. Furthermore the Opinion data management requirements are a subset of the fish and wildlife data requirements for the Columbia Basin as a whole. This data management plan directly addresses the data requirements for RPA Actions 179-199 while integrating the regional fish and wildlife data management requirements. It surveys other data and information management activities in the Columbia River Basin and proposes ways to integrate the proposed opinion process with these basinwide activities.

Data management in the IP is primarily aimed at satisfying RPA Action 198 that states:

> "The Action Agencies, in coordination with NMFS, USFWS, and other Federal agencies, NWPPC, states, and Tribes, shall develop a **common** data management system for fish populations, water quality, and habitat data." (emphasis added)

Data system development cannot proceed in the abstract without detailed knowledge of precisely what, where, and when data will be collected, and with what methods and standards it will be collected. The data needs of the IP will be based on detailed program plans made to implement RPA Actions 179-197 and 199. The status/effectiveness monitoring, hydro, hatchery, and estuary/ocean workgroups will define their data management requirements, including the data attributes,[10] collection protocols, methods, standards, users, reporting requirements, etc. The data management subgroup is charged with developing a data management system to support the plans developed by the other subgroups with this effort conducted collectively with the subgroups in an intensive effort to standardize data collection.

The data management workgroup will also attempt to develop its plan within a regionwide information structure as it develops. This will include decisions about technical features such as architecture, integrated GIS, web enabling, data encryption, user passwords, hardware and

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[9] For the purposes of this document "data" could include raw data, derived data, corrected data, reports, maps and all related metadata, depending on the needs of the users.

[10]

software, and other technology necessary to support the system design. Important high-level decisions remain to be made on administrative responsibility, funding, and the extent to which information system standards and protocols will be uniformly adopted across all RME programs throughout the region.

As a part of its preliminary research the RME data management workgroup convened a team of experts to consider RME data management challenges and recommend strategies. The findings of the group are included in the data management plan strategy below.

a. 1) Overall RME Data Management Objectives

Systemwide Data Management
Develop a common system for the efficient and effective collection, management, and distribution of information relating to RME needs as specified in 2000 FCRPS Biological Opinion for action items 179 to 199. Ensure that the system will be compatible with the fish and wildlife data management requirements for the Columbia River Basin. Participate in the incorporation of the FCRPS RME database into a regional data management system when it is developed.

- Develop an overall RME information system architecture – a detailed blueprint of the design of the RME system.
- Take advantage of existing potential data centers. Include information portals/distributed database management system tools as necessary to consolidate data and communicate using the Internet.
- Develop a data management cost sharing approach to achieve 2000 FCRPS requirements.

1. Promote the free exchange of information and development of a systems view of the Columbia River Basin.

   Data Management Prototype (Habitat)
   Develop a data management program that identifies research monitoring and evaluation data management needs for the three pilot subbasins that have been identified by the Status Monitoring and Action Effectiveness Monitoring Teams – one each in Idaho, Oregon, and Washington – with the cooperation of local, state, tribal, and Federal parties.

   - Recognize the need to develop an information system(s) from the ground up in a modular fashion so that the system(s) meets the practical needs of the local users while meeting the legal and administrative requirements of the region.
   - Perform a scoping exercise. Develop specific objectives, deliverables, timelines, and budgets for a prototype.
   - Develop and use common protocols and techniques for data collection, development, storage, and distribution.

- Ensure that data can be shared as needed for timely analysis.

- Ensure properly documented metadata for published data and information. Include data pedigree and metadata and clearly distinguish primary data and derived information.

  - Adopt geo-spatially reference standards using repeatable standard methods. Where possible make the data available as spatial data layers.

2. Provide security for data, systems and participant information where necessary.

3. Work collaboratively and cooperatively to obtain necessary data and improve data quality.

b. 1) Identify Implementation Plan Strategies and associated RPAs covered

Background
To support the decision-making process the RME Data Management Team solicited input from regional experts with experience in developing or managing large-scale regional information systems. The strategic findings of the group were as follows:

- A key discussion concerned how to meet the FCRPS Opinion needs in the short term and how to do this efficiently and in a way that allows integration and compatibility of the information with other regional data management efforts. In particular an interim repository is needed for the upcoming field season. We agreed to pursue prototypes.

- A key point was not to focus or decide on technology/database solutions until after the specific needs, data outputs, and data inputs of the planned user group have been thoroughly defined in a detailed needs assessment with the creation of a data dictionary.

- The Team agreed that data analysts should perform the data dictionary/needs assessment.

- Following the creation of a prototype data dictionary for three pilot basins, the Team would evaluate the specific data management needs and determine if existing data management systems are adequate. If not, a more formal system analysis would be done to make decisions about how best to meet those needs through: (1) augmentation of existing management systems (2) the establishment of a new centralized data management systems, or (3) a the creation of a distributive system of subbasin databases and portal efforts. Emphasis was made on the benefits of achieving the results in an iterative and modular fashion rather than through a large-scale development which might solve all problems at one time but at the risk of not meeting critical time and functional needs.

- The Team agreed that with respect to the hydrological foundation for the RME effort the 1:24,000 GIS enabled data from the USFS/BLM/STATE hydrographic effort will be used where it is available. This process involves the use of a shared data set based on common standards with built in quality control and quality assurance. It supports the mounting of verified and validated field data on a common server for widespread use, a function that is similar to that needed for RME.

- Finally there was discussion about how the RME data collection effort relates to the Columbia River Basin Cooperative Information System (CBCIS) initiative. The purpose of the CBCIS project is to develop regional agreement on information system standards and protocols, and determine if an overall information system architecture or design would best serve the Basin. Currently a consultant group, Science Applications International Corporation (SAIC) is completing a high level needs assessment in the Basin. While the RME data is considered a subset of the overall regional data, it is unlikely at this time that the results of the SAIC needs assessment will be completed or acted on in time to provide for the needed RME data collection. Meanwhile the RME Team will implement an interim plan to meet the obligations under the FCRPS Opinion requirements and coordinate its plan with the CBCIS effort.

(a) Performance Indicators and Standards

a. 1) Identify performance indicators

Programmatic performance indicators for data management programs will include:

1. Meeting defined user needs as specified in the design documentation for each deliverable.
2. On time delivery based on the project plan.
3. On budget delivery based on the project plan.
4. Satisfies Internal Validation and Verification (IV&V) reporting requirements.
5. Meets overall RME system requirements as in RPA 198.

a. 2) Identify Performance Standards or plans for development and any issues (if applicable)

Neither the Columbia Basin as a region of the action agencies as a group have adopted standards, for overall system development or for individual information system components, for example: for completing metadata, for data collection methods, for GIS spatial data, or for compliance with a common data-dictionary.

To the extent that individual agencies have applied standards they are not uniformly applied. The Columbia Basin Cooperative Information System (CBCIS) project is addressing the need for standards, and, if there is support for such a regional approach, then development of regional standards/protocols are likely to be amongst the most important priorities. Depending on the timing these may benefit data management for the Biop. Unless CBCIS develops standards in time to benefit this Biop effort, the Action Agencies and the NMFS will need to adopt standards for data management tasks under the Biop.

The federal government has a set of "best practices" or guidelines for application and use by agencies involved in enterprise level system development. These are high-level standards that are appropriate to the RME data management effort and are referred to this plan - see footnote 3 "Federal Enterprise Architecture Framework version 1.1 September 1999."

(b) RME needs assessment

Detailed professional level assessments are necessary for prototype RME programs and for overall RME data management planning. A detailed needs assessment is a process undertaken by information system data analysts to identify and document, at a very fine level of detail, the attributes of the information that will be collected, the products that will be produced, and the business (or administrative) rules that will govern system operation. The prototype assessment should anticipate how the prototype will fit into a regional information system architecture.

b. 1) General description of FCRPS Opinion RME requirements

The FCRPS Biological Opinion Reasonable and Prudent Alternative Action 198 states:

> "The Action Agencies, in coordination with NMFS, USFWS, and other Federal agencies, NWPPC, states, and Tribes, shall develop a common data management system for fish populations, water quality, and habitat data."

The Actions Agencies thus are charged with addressing the data requirements for RPA Actions 179 to 199 of the BiOp in the context of a common regional data management system. This section of the data management plan discusses the requirements of the BiOp. The integration of the BiOp requirements into a common system is addressed in the following work plan.

The BiOp requirements for data management must support the RME Plan principle components of Population/Environmental Status Monitoring, Action Effectiveness Research, and Critical Uncertainties Research associated with the needs of check-in assessments and RPA Actions 179 to 199. Specific descriptions of these assessments and RPA actions can be found in Chapter 9 of the BiOp.

b. 2) General description of current projects and programs addressing these needs

General reviews of current programs and projects:

- The May 2000 Independent Scientific Review Panel's *Review of Databases Funded through the Columbia Basin River Fish and Wildlife Program* identified specific information system development needs and was critical of the current system.

- In November 2000 the National Science and Technology Council Committee on Environment and Natural Resources concluded in it's *From The Edge - Science to Support Restoration of Pacific Salmon* that "Current monitoring will need to expand and, data storage/retrieval, and evaluation processes will need to evolve in complexity and increase capacity. Monitoring and data systems need to keep pace to facilitate improved quantitative approach to salmonid recovery and restoration."

- The 2001 *Inaugural Annual report of the Columbia Basin Fish and Wildlife Program 1978-1999* noted that "Since 1978, Bonneville's fish and wildlife expenditures total $3.48 billion" and made this major conclusion: "While we report on Bonneville's fish and wildlife expenditures, our report also notes the confusing state of fish and wildlife data collection and reporting in the basin. This must improve. When it does, accountability to the public for the Council's program and Bonneville's expenditures will also improve."

- Most recently the GAO-02-612 report: *"Columbia River Basin Salmon and Steelhead – Federal Agencies' Recovery Responsibilities, Expenditures and Actions"* noted that [While] Federal agencies have undertaken many types of recovery actions and, although these actions are generally viewed as resulting in higher numbers of returning adult salmon and steelhead, there is little conclusive evidence to quantify the extent of their effects on returning fish populations….The data to quantify the effects of these actions on fish populations are generally not available….." While the GAO report did not comment directly on the capability of the regional information system to manage available data, the implication of the GAO report is that critical data, essential for determining the effectiveness of recovery actions is not being collected. However, when the comments of the GAO report are put together with the other regional reports it is clear that there are accountability problems concerning <u>both</u> the availability of data (data collection quantity and quality) and regional data management capability.

Regional data management development projects underway in the Columbia basin include the following:

- The funding process for the FY 03 Columbia Basin Mainstem and other funding proposals that include proposals for RME data collection, analysis, and management. Significantly there is no regional information plan or regional information architecture to guide these decisions. Only a few proposals address RME needs.

- The Columbia Basin Cooperative Information System (CBCIS) project, which is aimed at identifying regional needs for information system development for the Columbia Basin (of which RME is considered a highly relevant subset). The CBCIS initiative results from a memorandum of agreement between the NWPPC and the NMFS. The NWPPC has employed a contractor, Science Applications International Corporation (SAIC) to identify regional needs. A report is expected from SAIC in December 2002.

- The Regional Ecosystem Office (REO) effort, an interagency support effort to develop and manage regional data sets, for example 5th and 6th HUC watershed delineation data and 1:24,000 forest and watershed data.

- Data Access in Real Time (DART). DART provides access to current and historic information from sources such as StreamNet, the Fish Passage Center, and others. As such it is considered a "second tier" database. DART uses a report generator to allow users to select one or more routinely prepared documents, graphs, etc., for viewing and printing.

- The Fish Passage Center (FPC). The Center provides specific analysis of alternatives for fish passage, such as those used for decisions on flow augmentation, spill, adult passage and the like. It provides analysis and reports to state water quality agencies. The FPC designs and oversees the Smolt Monitoring Program and manages the Comparative Survival Study.

- StreamNet is the Northwest Aquatic Resource Information Network. StreamNet operates a PC based database containing fully referenced data and an on-line query interface. It maintains a library and reference system for use in monitoring and evaluation of Columbia river fish stocks. StreamNet prepares an annual report on status of runs including some data on environmental conditions that could affect status. StreamNet does not evaluate the implications of published data.

- PIT Tag Information System (PTAGIS) is a program to provide database systems management and operations for the collection and distribution of PIT (Passive Integrated Transponder) data to all interested parties. It operates transponders on hydroelectric dams on the Columbia and Snake rivers and provides user training and support.

- The Coded Wire Tag Recovery (CWT) and Regional Mark Information System (RMIS). The CWT program provides for a joint Washington and Oregon sampling effort for coded wire tags while the RMIS provides for the recovery and management of data from the tags which are made available through the Pacific States Marine Fisheries Commission Regional Mark Information System.

b. 3) Needs Assessment

Summary

- A more comprehensive scoping of existing regional data management projects/goals/ needs

- A formal comparison of regional data management goals/needs compared to the FCRPS Opinion goals/needs

- The development of a FCRPS RME information system architecture or blueprint that is consistent with regional needs

- The development of an information system(s) from the ground up in a modular fashion so that the system(s) meets the practical needs of the local users while meeting the legal and administrative requirements of the region

Background to Needs Summary

The FCRPS Opinion sets programmatic and project reporting obligations at years 3, 5, and 8 of the Opinion. The Opinion RPA Action 198 calls for a common data management system for the region that is sufficient to meet these obligations. No existing regional data management system meets the data management requirements of the Opinion.

General data management needs for the Biop are well understood. They include a need to communicate via the Internet, geo-spatially reference data for use with geographic information system tools, a data quality control program that includes data collection standards, information portals or other tools for the purpose of consolidating key data sets, and employment of current information system technologies (for example, GIS Spatial data technology, integrated database technologies such as Oracle, and web enabled data exchange and information system enterprise management). These needs are currently not met by any existing regional data management system.

Ultimately regional data management should be conducted within a formal information system built at an enterprise level, for example as described in the Federal Enterprise Architecture Framework.[11] A formal approach would systematically develop awareness of the problem, build consensus on the approach, assess the extent and details of the project, undertake renovation and rebuilding of existing information infrastructure, test the solutions, and deploy the preferred solutions. The CBCIS effort (see above) may meet the scoping requirements for a formal architecture. However it will likely not provide an architecture or detailed needs assessment in the timeframe needed for the FCRPS Opinion.

There are also important overall architectural choices with at least two approaches to information system design:

1. A Distributed Database Management System (DDBMS). A DDBMS provides the tools and protocols to connect multiple users and databases into a coherent information system and provides considerable advances over the informal resources currently available through the Internet. Users have the benefit of using common protocols for information sharing, data inventory, data transfer and interchange, metadata, data recovery, data collection, data distribution, confidentiality, and version control. Users also would be able to use the new system without needing expert knowledge in computer networking and data transformation.

However a DDBMS system with weak or diffuse central control over the institutions involved in data collection, and distribution[12] presents many challenges. DDBMS systems rely on consistent and repeatable application of common technologies and data management tools. Given this reality there may be circumstances where portal development offers a more efficient and effective architecture. Moreover, it is possible to use combinations of DDBMS and portals, depending on the actual needs of the users and the maturity of existing systems. Designers of RME architecture need to stay open to all these possibilities. There is also a gap with respect to legal considerations. Because of legal requirements of "maintaining a record" of administrative decisions under a Section 7 Endangered Species Act consultation, the Federal Action Agencies and regulatory agencies cannot rely entirely on existing ad-hoc regional arrangements for data management.

2. A Centralized Information Management System. A centralized system provides some advantages over a DDBMS. These advantages include central control over user access and security, standardized formats for managing data and accessing it, and the ability to provide a consistent approach to managing many different versions of documents. There may also be efficiencies arising from economies of scale and staffing. However they also have disadvantages, they require a very high level of agreement between participants to join such a system. Where the participants have different mandates, constituents and/or business objectives the operational agreements and cost sharing arrangements can be difficult to overcome. A

[11] Federal Enterprise Architecture Framework version 1.1 Sept 1999. See www//CIO.gov

[12] As is the case for current data management arrangements between and amongst institutions in the Columbia Basin.

further weakness is that entire centralized systems can become dependent on a single (or limited) set of technologies which can restrict opportunity to take advantage of improved technology.

Meanwhile, the IP data management plan proposes an iterative modular process in parallel to CBCIS and architectural considerations that will develop a prototype data needs assessment and data dictionary in a few pilot subbasins of the Columbia River Basin. Detailed and exacting RME needs assessments are necessary to ensure consistency, completeness, and integrity of a regional system.

There are significant pitfalls to be considered when developing a regional database concurrently with pilot programs. For example, standards can be developed in advance of pilot programs, or they can be developed concurrently with the expectation that at least some of the prototypes will need reengineering if different standards are adopted. Data management system developers need to be aware of and explicit about their choices and the consequences of such tradeoffs. The most probably consequence of reengineering is likely to be increased costs attention to standards is critical.

(c) Action Plans for meeting RME Needs

1. Research requirements are not a part of the RME Data Management effort.

2. Data Management Work Plan

The following table outlines the data management work plan. The Data Management Subgroup recommends that a portion of Mainstem/Systemwide Project 35048 be supplemented and funded to satisfy the work plan.

Strategy	Objective	Task	Estimated Schedule/Costs
Systemwide Data Management	1. Review existing data management projects/ goals/needs and compare to FCRPS goals/needs. Includes: development of cost sharing arrangements and MOA's between the agencies.	1. See 1-3 below table.	1. This task requires a detailed needs assessment and scoping. The task is estimated to take 3 to 6 months for a regional coordinator/project manager and 2 to 3 data analysts.[13]
	2. Develop common FCRPS RME information system plan together with architecture, standards and protocols.	1. See 4-7 below table.	Time, detailed tasks and costs depend on scoping above. However, significant progress on a project of this scale and complexity should not be anticipated without a substantial information system development team for a 2- to 3-year effort.
Habitat	1. Scoping pilot data	1. Develop objectives,	5K (1 month)

[13] This assumes that more detailed needs assessment, standards and protocol development is necessary beyond what will be delivered in the CBCIS SAIC report.

Strategy	Objective	Task	Estimated Schedule/Costs
Prototypes for three sub basins	management project	deliverables, timelines and budget.	
	2. Pilot data management needs assessment. Coordination of standards and protocols with system wide needs.	1. Agree on data needs, outputs, and model inputs. 2. Agree on data protocols, needed spatial data layers, QA/QC methods, etc. Ensure consistency with RME workgroups. 3. Review existing data for compatibility. 4. Develop a common data dictionary for needed data. 5. Develop business rules for operating pilot information system. 6. Coordinate and adopt systemwide standards and protocols for data sharing. 7. Coordinate and adopt systemwide cost sharing agreements.	50K (5 months)
	3.Development pilot information management system.	1. Review needs against available budget and if necessary prioritize. 2. Design and develop information management solution. Ensure consistency with regional infor-mation system. 3. Build, test and document the pilot system.	135 K (3-6 months following needs assessment, depending on staffing level)
	4. Modify pilot -Operate pilot system for one year	1. Deploy pilot system 2. Monitor and review performance	50-70K, depending on extent of changes[14]

1. Include general participant goals for each participating agency
(This example is for NMFS, other participants would have their own):

- Recover protected fish species, build sustainable fisheries, and protect and restore critical fish habitat;

[14] Does not include possible new data acquisition costs. New data needs would be identified as part of the needs assessment.

- Identify risks and opportunities for ecosystem protection and restoration;
- Make data and information accessible, integratable, and usable to support defensible and scientifically sound decision-making related to the necessary protection, and maintenance, of Columbia River Basin fishery resources.

2. Develop background information

This information sets the stage for considering and making system changes to meet MRE goals, and provides a basis for understanding the consequences of the changes.

Identify FCRPS BO data management roles and responsibilities for RME data management:

- National Marine Fisheries Service....
- Bonneville Power Administration…
- US ACE…
- BOR…
- USFWS

Recognize other potential data sources:

- Columbia Basin Tribes....
- CBFWA
- Northwest Power Planning Council....
- Local governments....
- State agencies....
- Other Federal agencies....
- Federal Caucus or other interagency entity....
- Existing data management programs (Dart, StreamNet FPC, CWT, PITAGIS, etc....
- Regional Assessment Advisory Committee....
- Independent Science Advisory Board....
- Citizen/environmental groups….

Identify relevant information management system reports or documents: (for example):

- 2000 FCRPS Biological Opinion;
- Fish & Wildlife Program 2000 Plan Amendments;
- ISRP report;
- Subbasin Assessment Template;
- All-H paper; and,
- other reports.

Identify critical legal issues (for example):

- Are there intellectual property rights or other information ownership issues?
- What are the FOIA and other legal obligations for data management?
- Do all users have equal legal rights to the information?

<u>Identify budget and staffing needed for RME</u>

- What are the current funding arrangements for information system management?
- What are the current staffing and information skill levels?
- Are there critical staffing gaps? Is there adequate funding for the development? For deployment?

<u>Identify current organizational and system infrastructures</u>

- System infrastructure detail would include descriptions of operational databases, hardware, software and networking resources, analytical tools, and would identify dependencies on other systems.

3. Define Required Data Management System Functions and Needs

<u>Support collection of scientific data</u>

- Support collection of RME data.
- What data will be collected, when, where and by whom?
- What input devices technologies will be supported?
- If the data is already being collected but needs to be used for analysis, where will it come from and how will it be managed prior to analysis?
- Are data collections standards in place and what are they?

<u>Support the collection of metadata.</u>

- What standards will be used?
- Who will maintain metadata?

<u>Support access to collected data and other information</u>

- Who will have access, at what times, and for what reasons?
- Who will the gatekeeper/s be?
- What security system is needed? Would public key infrastructure, digital signatures or other methods be used?
- How important is the timeliness of access?

<u>Support information use</u>

- Will the RME data management system provide access to these data and/or provide or develop tool sets that enable analysis of these data?
- Will the access be provided on line, through dial up, through the web or both?
- Will paper documentation and reports be provided?

<u>Support system maintenance</u>

- For example, how will users be registered, and firewalls maintained?
- What firewalls are necessary?
- How will records be maintained and archived?
- What master data will be maintained, for example species lists?
- Who will have authority to update, delete, copy, or archive records?

<u>Support archives</u>

- How will the archive/legacy function be provided?

4. Define Necessary Operational Processes

What are the critical operational processes that must be included in the information system design? For example, if secure access to the information system is needed, the system design must accommodate this. If security needs dictate encryption of data transmission then an additional operational layer is needed at the system design level. These issues relate directly to necessary functions and needs detailed in 3.0 above.

5. Define System Architecture

Evaluate options for a RME system architecture. What would the RME system architecture look like? Would it be a subset of a Columbia regional information system architecture or would it stand alone? How would it relate to existing architectures, for example the StreamNet or the NWFSC Salmonid database architectures?

Standards for overall system dependability, needed development of linkages to existing distributed databases, support of web enabled access, analytical capability, metadata, and responsibilities for system maintenance need to be considered and developed.

The design would need to specify the way (at least) each of the following system components interact and combine to satisfy the stated functional/operational needs:

- Database/s,
- Communication,
- Tools,
- Security layer and firewalls,
- Web application,
- Transactions,
- Data Archiving,
- Internet Services, and
- GIS Repository.

6. Define Reporting Standards

<u>The plan should include specific standards for:</u>

- Metadata,
- Geospatial information,
- Scientific reporting and sampling (unless otherwise specified), and
- Regional data consistency (how is the data going to be used by other data users).

7. Complete Design Review or Develop Prototype

A design review should be completed or a prototype built and tested to see whether the system can meet defined functional and operational needs. NMFS prefers prototypes.

8. Define System Specifications and Documentation

These specifications and the design should be sufficiently developed and detailed to fully support the system build by a third party through an RFP or other similar process.

- Database Specification,
- Security and Access Specification,
- Communication Protocol Specification,
- GIS Specification,
- Administration Specification,
- System Maintenance,
- Web Site and Form (page) Specifications,
- Prescriptive Performance Standards, and
- Master Data Specifications.

The plan should include cost and time estimates for all component parts for each of the following:

- System Project Planning,
- System Design,
- System Build,
- System Testing,
- System Deployment, and
- System Maintenance and Upgrading.

9. Develop Administrative/Organizational arrangements (logistics)

The plan should include a review of administrative/organizational arrangements to ensure adequacy of staffing, funding, and planning for equipment purchases for deployment. The plan should allow understanding of what system will be built, what the system will do, what skills and resources are necessary to deploy and maintain the system, and, what if any will be the implications for the pre-existing organizational arrangements identified in 2.0 above. The plan will address how current problems will be solved and emerging needs will be met.

Alternatives should be addressed in the planning process. For most system components there will be alternatives.

The plan should include details of administrative/organizational responsibility and funding arrangements for each part of the plan - to address at least the following questions:

- Project Planning - a detailed project plan is necessary;
- Approving Design,
- System build,
- Deployment,
- Maintaining the system,
- Operating the system, and
- Training for operators and users.

Since it is likely that many groups will have particular and potentially different interests in the data management system, the plan would need to establish clear mechanisms through which system operation would serve to meet all interest's needs. Memoranda of understanding or operational agreements may be necessary.

10. Build and Deployment

The project plan should include time schedules for all components and deliverables (near and longer term) and cost estimates for each part of the development including deployment. A full life cycle approach to project planning and cost analysis is needed. Instead of a formal design review (in section 3.5.2.7 above) prototypes may be built to fully test the system and provide a more realistic basis for creating documentation and overall design. Validation and verification should be completed following deployment.

3. Additional direction from the Opinion that may not have been treated in the GAP or not explicitly linked to the RPA.

None.

4. Distinguish needs as categorized by the 3 primary RME components.

Refer to database need assessments of other RME workgroups.

Table of Work Group Subject Areas and Data Management Roles

RME Work Group	RME Biop Component	Systemwide Data Management Role – RPA 198	Pilot data management program
Tributary Habitat	Population and Environment Status Monitoring	Participant/Supporter	Proposed
	Action Effectiveness Research	Participant	Proposed
	Critical Uncertainty Research, Extra-Mortality	Participant	Proposed
	Implementation and Compliance	Participant	Proposed
Hydro	Population and Environment Status Monitoring Life Stage Survival	Participant	Not known
	Action Effectiveness Research Dam Research	Participant	Not known
	Critical Uncertainty Research, Extra-Mortality	Participant	Not known
	Implementation and Compliance	Participant	
Estuary/Ocean	Population and Environment Status Monitoring	Participant	Not known
	Action Effectiveness Research	Participant	Not known
	Critical Uncertainty Research, Extra-Mortality	Participant	Not known
	Implementation and Compliance	Participant	
Hatchery Harvest	Population and Environment Status Monitoring	Participant	Not known
	Action Effectiveness Research	Participant	Not known
	Critical Uncertainty Research, Extra-Mortality	Participant	Not known
	Implementation and Compliance	Participant	
Data	Data Management tasks	Responsible for RME	Develops pilot

RME Work Group	RME Biop Component	Systemwide Data Management Role – RPA 198	Pilot data management program
Management		Data Plan including: cost sharing, system architecture, assessing quality of regional databases, and development of data management standards, protocols.	program for collection of RME data management across pilot efforts.

G. Summary of Projects, Proposals, and Gaps

(Table to be added)