*This is not a final federal agency product. Rather, it is a pre-decisional document prepared by the Action Agencies that reflects present understandings of currently available information and analyses, and of the progression of discussions with the sovereigns in the collaborative process. Revisions and refinements are to be expected based on further discussions with the sovereigns over new and modified proposed federal actions upon which the action agencies will ultimately consult. Finally, the information in this product does not constitute an analysis of whether the identified measures would or would not jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Furthermore, this document does not in any way interpret or apply the regulatory definitions of the statutory phrases "jeopardize the continued existence of" and "destruction or adverse modification."*

# Research Monitoring and Evaluation (RM&E) Proposed Action Summary

**RM&E Action Objective for All ESUs:** Perform RME to address compliance monitoring, effectiveness monitoring, and critical uncertainties research related to the implementation of FCRPS ESA actions.

The following RM&E actions will provide information needed to support adaptive management, demonstrate accountability, and guide hydro and offsite actions to achieve desired biological results. RME will address the following management questions related to FCRPS ESA actions:

- Are actions being implemented as proposed? Compliance Monitoring
- Are performance standards and targets for each ESA listed ESU and steelhead DPS being achieved? What is the effectiveness of specific types of actions in addressing limiting factors? Status and Effectiveness Monitoring
- Are there management questions or limiting factors that require further understanding? Critical Uncertainties

The proposed actions have and will continue to be coordinated through regional RM&E collaboration processes and are also intended to be consistent with the NMFS RM&E Guidance for Recovery Planning and Delisting. The Action Agencies currently fund extensive RM&E programs for the FCRPS, totaling more than $75 million per year. Implementation of these RM&E actions will continue to be coordinated through existing program project selection and funding processes including NPCC and AFEP. The following RM&E actions will be funded within those programs, while at the advancing the goal of shifting a greater percentage of spending in these programs to on-the-ground mitigation actions which provide direct benefits to salmon and steelhead. To accomplish this balancing of on-the-ground actions with RME and data management, prioritization of these new RM&E activities, with some potential reprioritization of existing activities, may be desirable. RM&E funding might also be leveraged through cost-sharing arrangements with other federal and state agencies, or potential use of shared savings.

The Action Agencies will undertake RM&E in the following nine areas. Tables of specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for RM&E are identified in Appendix 1.

- Fish Population Status

- Hydrosystem
- Tributary Habitat
- Estuary and Ocean
- Harvest
- Hatchery
- Predator
- Coordination and Data Management
- Project Implementation and Compliance Monitoring

The Action Agencies have identified performance measures (metrics) that will be monitored and evaluated relative to performance standards (benchmarks) and performance targets (longer-term goals) to assess progress and inform adaptive management actions. We will be monitoring two aspects of performance: 1) Programmatic and 2) Biological and Environmental. Programmatic performance will be tracked through project implementation and compliance monitoring. Biological and Environmental performance measures are tracked and evaluated through status monitoring, action effectiveness research and critical uncertainty research in combination with existing and developing quantitative models.

Performance standards will be monitored frequently to ensure accountability and adherence to proposed actions with potential contingencies or other time critical corrective actions. Performance targets will be evaluated over longer time periods as new information and learning is applied through analytical models to check for progress toward expected life stage survival improvements and trends in population performance. Performance targets will inform longer term adaptive management decisions and prioritization of options across populations with different relative needs.

## RME Strategy 1: Monitor Status of Selected Fish Populations Related to FCRPS Actions

**Funding Source(s):** BPA Fish and Wildlife Program direct funding, Corps of Engineers O&M and Columbia River Mitigation Program, and Bureau Congressional appropriations for Columbia/Snake Salmon Recovery.

**Rationale:** Monitoring status of selected populations supports future examination of recovery and survival metrics and trends for all Hs, including actions by the FCRPS and others.

**What's New:** Review and potential modifications to increase focus and value for existing AA status monitoring, and expansion to address a critical deficiency in regional monitoring of Snake River B- Run Steelhead; strengthened commitments to collaboration.

### 1.0 Fish Population Status Monitoring Approach

**Management Questions:** The primary management questions regarding information on fish populations for the FCRPS are as follows:

- What are the abundance, productivity, and spatial distribution of ESA listed populations affected by the FCRPS?
- What is the proportion of ESA listed populations that are of hatchery origin?

**Approach:** The Action Agencies will be using population performance information reported in the periodic population status reports from NOAA and in annual abundance estimates in the CBFWA State of the Resource reports to provide context for performance of FCRPS actions in aggregate with other regional actions and environmental conditions. We expect these status reports will continue to provide performance measures for trends in abundance and productivity and assessment of spatial diversity conditions.

The Action Agencies will also be funding specific status monitoring related to FCRPS actions. These projects are undergoing review and potential modifications to increase their focus and value for monitoring critical populations, and they are being expanded to address a critical deficiency in the regional monitoring of Snake River B- Run Steelhead.
See Table 8, Appendix 1 for specific projects that are currently being implemented during the FY07-FY09 period that contribute information to regional assessments of fish population status. Additional fish population status monitoring is also obtained as ancillary information under several projects listed under the hydro, habitat and hatchery project tables also in Appendix 1.

**Performance Measures:** Population specific performance measures include fish abundance, average recruits per spawner, lambda (annual population growth rate), abundance trends, and population viability extinction risks. The majority of these performance measures and associated monitoring actions are being implemented through the programs and mandated responsibilities of regional fish management agencies. A subset of these fish population performance measures are currently obtained from Action Agency funded projects.

**Action: Fish Population Status Monitoring Actions**

Fish population status monitoring is a primary responsibility of regional fish management agencies and is being implemented for most populations through agency programs. The Action Agencies will enhance existing fish population status monitoring performed by fish management agencies through the following proposed actions:

- *Implement and maintain the Columbia River Basin PIT Tag Information System.*
- *Monitor adult returns at mainstem hydro electric dams using both visual counts and the PIT tag detection system (See Hydro section).*
- *Monitor juvenile fish migrations at mainstem hydro electric dams using smolt monitoring and the PIT tag detection system (see Hydro Section).*
- *Fund status and trend monitoring as a component of the pilot studies in the Wenatchee, Methow and Entiat River Basins in the Upper Columbia, the Lemhi and South Fork Salmon River Basins and the John Day River Basin to further advance the methods and information needed for assessing the status of fish populations.*
- *Provide additional status monitoring to ensure a majority of Snake River B-Run Steelhead populations are being monitored for population productivity and abundance.*
- *Review and modify existing AA fish population status monitoring projects to improve their compliance with regional standards and protocols, and ensure they are prioritized and effectively focused on critical performance measures and populations.*

- *Fund marking of hatchery releases from Action Agency funded facilities to enable monitoring of hatchery-origin fish in natural spawning areas and the assessment of status of wild populations.*
- *Report available information on population viability metrics in annual and comprehensive evaluation reports.*

**Action: Collaboration Regarding Fish Population Status Monitoring**

Fish population status monitoring is a primary responsibility of regional fish management agencies and is being implemented for most populations through agency programs. The Action Agencies will enhance existing fish population status monitoring performed by fish management agencies through the following collaboration commitments:

- *Support the coordination, data management, and annual synthesis of fish population metrics through Regional Data Repositories and the CBFWA State of the Resource report.*
- *Facilitate and participate in an ongoing collaboration process to develop a regional strategy for status and trend monitoring for key ESA fish populations and an associated regional agreement for joint funding and implementation. This monitoring strategy will be coordinated with the status monitoring needs and strategies being developed for hydro, habitat, hatchery, harvest and estuary/ocean.*
- *Provide cost shared funding support and staff participation the PNAMP fish population monitoring workgroup and NED to advance regional standards and coordination for more efficient and robust monitoring and information management.*

## RME Strategy 2: Hydrosystem RM&E

**Funding Source(s):** Corps of Engineers O&M and Columbia River Fish Mitigation Program funding. BPA – direct funding.

**Rationale:** Evaluating the effectiveness of hydro actions and critical uncertainties is a central feature of the FCRPS ESA responsibilities.

**What's New:** Additional actions that include PIT tagging of UC Chinook and steelhead and SR sockeye if feasible.

### 2.0 Hydrosystem RME

**Management Questions:** The following are the primary management questions with respect to FCRPS hydro passage actions. Hydro RM&E actions described in this section are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

- Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets?
- Is each project in the hydropower system safely and efficiently passing adult and juvenile migrants?
- What are the most effective configurations and operations for achieving desired performance standards and targets in the FCRPS?

- What is the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville?
- Under what conditions does in-river passage provide greater smolt-to-adult return rates than transport?

See Table 1, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Hydro RM&E. Additional, more detailed information supporting the identification of Hydro RM&E Proposed Actions is provided in Appendix 2.

**Performance Measures:** The biological and environmental performance measures for hydro are juvenile and adult system survival, juvenile dam passage survival, proportion of juveniles transported, fish and spillway passage efficiency, forebay behavior, tailrace egress and spill, discharge, and water quality at fish passage projects. Performance standards have been set for average juvenile dam survival for run-of-river spring and summer migrants and adult hydro system survival. Hydro PA programmatic standards have also been identified and will be annually monitored with project implementation monitoring. The expected increase in total juvenile system survival associated with the Hydro proposed actions has been set as a long term performance target for each ESU. This performance target will be assessed in the future using the same modeling approach used to assess the benefit of proposed actions within the BA, but using actual operations and configurations in place at the time of the performance evaluation. These estimates will be based on the most recent fish passage research applied within the COMPASS passage model, calibrated and validated by recent years' empirical survival data

**Action: Monitor and Evaluate Fish Performance within the FCRPS**

The Action Agencies will monitor the following biological responses and/or environmental attributes involved in passage through the hydro system, and report these estimates on an annual basis:

- *Monitor and evaluate juvenile salmonid dam survival rates for a subset of FCRPS projects.*
- *Monitor and evaluate juvenile salmonid system survival through the FCRPS, including estimates of differential post-Bonneville survival of transported fish relative to in-river fish (D) as needed.*
- *Monitor and evaluate adult salmonid system survival upstream through the FCRPS.*
- *Provide additional PIT tag marking of Upper Columbia populations to provide ESU specific estimates of juvenile and adult survival through the Federal mainstem dams.*
- *Assess the feasibility of PIT tag marking of Snake River sockeye for specific survival tracking of this ESU through the FCRPS.*
- *Develop an Action Plan for conducting hydro status monitoring (analytical approaches, tagging needs, methods and protocols) in ongoing collaboration with the state and federal fishery agencies and tribes. This will be done in coordination with status monitoring needs and strategies being developed for estuary/ocean, habitat, hatcheries, and harvest.*

**Action: Monitor and Evaluate Migration Characteristics and River Condition**

The Action Agencies will monitor and evaluate the following biological and physical attributes of anadromous fish species migrating through the FCRPS:

- *Monitor and estimate the abundance of smolts passing index dams.*
- *Monitor and describe the migration timing of smolts at index dams, identify potential problems, and evaluate implemented solutions.*
- *Monitor and document the condition (e.g., descaling, injury, GBT) of smolts at index dams identify potential problems, and evaluate implemented solutions.*
- *Monitor and enumerate adult salmonids passing through fishways in the FCRPS, identify potential problems, and evaluate implemented solutions.*
- *Monitor and describe the migration timing of adults at dams in the FCRPS, identify potential problems, and evaluate implemented solutions.*
- *Monitor and evaluate the TDG, temperature, turbidity and flow at projects in the FCRPS relative to performance objectives.*

**Action: Monitor and Evaluate Effects of Configuration and Operation Actions**

The Action Agencies will monitor and evaluate the following effects of the numerous operations and configurations implemented at projects in the FCRPS:

- *Monitor and evaluate the effects of existing spillways, modifications, and operations on smolt survival.*
- *Monitor and evaluate the effectiveness of traditional juvenile bypass systems and modifications to such, on smolt survival and condition.*
- *Monitor and evaluate the effectiveness of surface bypass structures and modifications on smolt survival and condition.*
- *Monitor and evaluate the effectiveness of turbine operations and modifications on smolt survival and condition.*
- *Monitor and evaluate overall dam passage with respect to modifications at projects.*
- *Monitor and evaluate the effectiveness of the juvenile fish transportation program and modifications to operations.*
- *Monitor and evaluate the effects of environmental conditions affecting juvenile fish survival.*
- *Monitor and evaluate the effectiveness of reducing predation towards improving juvenile fish survival.*
- *Investigate, evaluate and deploy alternative technologies and methodologies for fish passage and RM&E actions.*
- *Determine if actions directed at benefiting juveniles have an unintended effect on migrating adults (e.g., certain spill operations).*
- *Install and maintain adult PIT tag detectors in fish ladders at key dams in the FCRPS.*
- *Assess the feasibility of developing PIT tag detectors for use in natal streams and tributaries as appropriate to support more comprehensive and integrated all-H monitoring designs and assessments of stray rates.*
- *Monitor and evaluate the effects of fish ladder operations and configurations on adult passage rates.*

**Action: Investigate Hydro Critical Uncertainties**

The Action Agencies will fund selected research directed at resolving critical uncertainties that are pivotal in life cycle model analyses. These proposed actions include:

- *Investigate and quantify delayed differential effects (D) associated with the transportation of smolts in the FCRPS as needed.*
- *Investigate the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville.*
- *Conduct a workshop every other year with members of the Independent Scientific Advisory Board to review current research and monitoring approaches on post Bonneville mortality for transported and non-transported fish.*
- *Investigate, describe and quantify key characteristics of the early life history of Snake River Fall Chinook in the mainstem Snake, Columbia and Clearwater rivers.*
- *Investigate effects of adult passage experience in the FCRPS on pre-spawning mortality.*

## RME Strategy 3: Tributary Habitat RM&E

**Funding Source(s):** BPA – direct funding; Bureau Columbia Basin Salmon Recovery funding

**Rationale:** Evaluating the effectiveness of habitat actions that are being implemented as off site mitigation for dam effects is a central feature of the FCRPS ESA responsibilities.

**What's New:** Additional actions.

### 3.0 Tributary Habitat RME

**Management Questions:** The following are the primary management questions with respect to tributary habitat offsite mitigation actions. The RM&E actions described in this section are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

- Are tributary habitat actions achieving the expected biological and environmental performance targets?
- What are the relationships between tributary habitat actions and fish survival or productivity increases? What actions are most effective?
- What are the limiting factors or threats preventing the achievement of desired habitat or fish performance objectives?

See Table 2, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Tributary Habitat RM&E. Additional, more detailed information supporting the identification of Tributary Habitat RM&E Proposed Actions is provided in Appendix 3.

**Performance Measures:** Survival and productivity benefits for the aggregate of tributary habitat actions that are expected to be implemented in the periods FY07-09 and for FY10-17 have been estimated for individual populations and used within the Biological Assessment. These estimated tributary habitat benefits provide the long term biological performance targets

for individual populations. In addition, potential changes in limiting factors and overall habitat condition resulting from habitat actions implemented within the two time periods have been estimated based on local biologist input. Programmatic level performance standards have been set for annual tracking of project implementation (linked to expected changes in limiting factors and their habitat) projected for the periods FY07-09 and for FY10-17, which were used to estimate the long term survival benefits. RM&E will be used to confirm and improve our understanding of the relationships between different habitat actions, the environment and the survival and productivity performance measures. As this information is developed and relationships and models are updated, the AA will re-confirm the modeling estimates of expected survival improvements associated with actions.

**Action: Monitor and Evaluate Tributary Habitat Conditions and Limiting Factors**

Habitat status monitoring and limiting factor analyses are primarily the responsibility of agencies affecting or regulating tributary habitat areas; however, given the importance of this information to the diagnosis and effective planning of offsite mitigation actions, and the application of these data in complimentary action effectiveness evaluations, Action Agencies are proposing the following targeted actions:

- *Implement research in select areas of the pilot study basins (Wenatchee, Methow and Entiat River Basins in the Upper Columbia, the Lemhi and South Fork Salmon River Basins and the John Day River Basin) to quantify the relationships between habitat conditions and fish productivity (limiting factors) to improve the development and parameterization of models used in the planning and implementation of habitat projects. These studies will be coordinated with the influence of hatchery programs in these habitat areas.*
- *Implement status and trend monitoring as a component of the pilot studies in the Wenatchee, Methow and Entiat River Basins in the Upper Columbia, the Lemhi and South Fork Salmon River Basins and the John Day River Basin.*
- *Facilitate and participate in an ongoing collaboration process to develop a regional strategy for limited habitat status and trend monitoring for key ESA fish populations and an associated regional MOU for joint funding and implementation. This monitoring strategy will be coordinated with the status monitoring needs and strategies being developed for hydro, habitat, hatchery, harvest and estuary/ocean.*

**Action: Evaluate the Effectiveness of Tributary Habitat Actions**

The Action Agencies will evaluate the effectiveness of habitat actions through RM&E projects that will support the testing and further development of relationships and models used for estimating habitat benefits. These evaluations will be coordinated with hatchery effectiveness studies.

- *Action effectiveness pilot studies in the Entiat River Basin to study treatments to improve channel complexity and fish productivity.*
- *Pilot study in the Lemhi Basin to study treatments to reduce entrainment and provide better fish passage flow conditions.*

- *Action effectiveness pilot studies in Bridge Creek of the John Day River Basin to study treatments of channel incision and its effects on passage, channel complexity, and consequentially fish productivity.*
- *Project and watershed level assessments of habitat, habitat restoration and fish productivity in the Wenatchee, Methow and John Day Basins.*

## RME Strategy 4: Estuary Habitat and Ocean RM&E

**Funding Source(s):** BPA – direct funding; Corps appropriations through section 536 of WRDA 1999 and Columbia River Fish Mitigation Program

**Rationale:** Evaluating the effectiveness of habitat actions that are being implemented as off site mitigation for dam effects is a central feature of the FCRPS ESA responsibilities.

**What's New:** Several new actions

## 4.0 Estuary Habitat and Ocean RM&E

**Management Questions:** The estuary/ocean RME material here draws on the "*Plan for Research, Monitoring and Evaluation of Salmon in the Columbia River Estuary*" (Estuary/Ocean RME Subgroup 2004) and the "*Research, Monitoring and Evaluation – Conceptual Framework Outline*" (Sovereign Collaboration Group 2006). For the purposes of this document, the estuary/ocean is defined as the tidally-influenced portion of the river and its tributaries from Bonneville Dam to and including the plume and nearshore ocean; lower Columbia River tributary watersheds above tidal influence are not part of the study area.

The following are the primary management questions with respect to Estuary Habitat actions. The RM&E actions described in this section are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

- Are aquatic, riparian, and upland estuary habitat actions achieving the expected biological and environmental performance targets?
- Are the offsite habitat actions in the estuary improving juvenile salmonid performance and which actions are most effective at addressing the limiting factors preventing achievement of habitat, fish, or wildlife performance objectives?
- What are the limiting factors or threats in the estuary/ocean preventing the achievement of desired habitat or fish performance objectives?

See Table 3, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Estuary and Ocean RM&E. Additional, more detailed information supporting the identification of Estuary and Ocean RM&E Proposed Actions is provided in Appendix 4.

**Performance Measures:** Performance measures for the Columbia River estuary include reach survival, life history diversity, growth rates, and predation rates of juvenile salmonids and the bathymetry, topography, connectivity, and hydrology of estuary habitats. Survival benefits for

actions implemented in the periods FY07-09 and for FY10-17 for estuary habitat actions have been estimated for stream and ocean-type life histories and used within the biological assessment based on methods discussed and developed in the Remand Collaboration process. These estimated benefits provide the long term performance targets.

Performance standards have also been set for annual tracking of project implementation projected for the periods FY07-09 and for FY10-17 used to estimate the long term survival benefits. RM&E will be used to confirm and improve our understanding of the relationships between different estuary habitat actions, the environment and the survival and productivity performance measures. As this information is developed and relationships and models are updated, the AA will re-confirm the modeling estimates of expected survival improvements associated with actions. Specific performance standards, contingencies, and performance targets for estuary habitat actions are identified in more detail in the Accounting and Adaptive Management section.

**Action: Monitor and Evaluate Fish Performance in the Estuary and Plume**

The Action Agencies will monitor biological responses and/or environmental attributes, and report in the following areas:

- *Monitor and evaluate smolt survival and/or fitness in select reaches from Bonneville Dam through the estuary.*
- *Develop an index and monitor and evaluate life history diversity of salmonid populations at representative locations in the estuary.*
- *Monitor and evaluate juvenile salmonid growth rates and prey resources at representative locations in the estuary and plume.*
- *Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.*

**Action: Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions**

The Action Agencies will monitor and evaluate selected ecological attributes of the estuary, which could include the following:

- *Map bathymetry and topography of the estuary as needed for RM&E.*
- *Establish a hierarchical habitat classification system based on hydro-geomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.*
- *Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.*
- *Tabulate the amount of absolute acreage by habitat type that is restored or protected every year.*
- *Evaluate migration through and use of a subset of various shallow water habitats from Bonneville Dam to the mouth towards understanding specific habitat use and relative importance to juvenile salmonids.*

- *Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, substrate characteristics, dissolved oxygen, temperature, and conductivity, at representative locations in the estuary as established through RM&E.*
- *Monitor and report on indices of productivity in representative locations in the estuary and ocean.*

**Action: Monitor and Evaluate Habitat Actions in the Estuary**

The Action Agencies will monitor and evaluate the effects of a representative set of habitat projects in the estuary, as follows:

- *Develop a limited number of reference sites for typical habitats, e.g., tidal swamp, marsh, island, and tributary delta, to use in action effectiveness evaluations.*
- *Evaluate the effects of selected individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives.*
- *Develop and implement a methodology to estimate the cumulative effects of habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem controlling factors, structures, and processes affecting salmon habitats and performance.*

**Action: Investigate Estuary/Ocean Critical Uncertainties**

The Action Agencies will fund selected research directed at resolving critical uncertainties that are pivotal in understanding estuary and ocean effects, which could include the following:

- *Continue work to define the ecological importance of the tidal freshwater, estuary, plume and nearshore ocean environments to the viability and recovery of listed salmonid populations in the Columbia Basin.*
- *Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.*
- *Investigate the importance of early life history of salmon populations in tidal freshwater of the lower Columbia River.*
- *Continue development of a hydrodynamic numerical model for the estuary and plume to support critical uncertainties investigations.*

## RME Strategy 5: Harvest RM&E

**Funding Source(s):** BPA – direct funding

**Rationale:** Evaluating improved harvest actions that would allow more natural fish to spawning grounds is a feature of the FCRPS action.

**What's New:** Additional action.

## 5.0 Harvest RME

**Management Questions:** Key management questions related to FCRPS-sponsored harvest improvements are:

- What is the effect of acquiring more accurate and precise inriver harvest estimates on the resultant estimates of straying and adult passage survival?
- Can selective fisheries targeting hatchery fish or healthy populations reduce impacts on ESA listed populations?

See Table 4, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Harvest RM&E.

**Performance Measures:** No biological or environmental performance measures or targets for the FCRPS have been identified for Harvest.

**Action: Harvest RME**

The Action Agencies will fund selected harvest investigations linked to FCRPS interests:

- Evaluate the feasibility of obtaining PIT tag recoveries in Zone 6 to determine whether recoveries can help refine estimates of inriver harvest rates, upstream survival rates, and straying rates. For FY2007, focus on a pilot to test the feasibility of PIT tag recoveries in Zone 6 harvest (spring, summer, and fall chinook, summer steelhead).
- Evaluate Methods to Develop or Expand use of Selective Fishing Methods and Gear.
- Evaluate post release mortality rates for selective fisheries.
- Support coded-wire tagging and coded-wire tag recovery operations that inform survival, straying, and harvest rates of hatchery fish by stock, rearing facility, release treatment, and location.
- Investigate the feasibility of genetic stock identification monitoring techniques.

### RME Strategy 6: Hatchery RM&E

**Funding Source(s):** BPA – direct funding

**Rationale:** Hatcheries provide central mitigation for FCRPS effects. Safety net and conservation hatcheries and hatchery reforms funded by the Action Agencies should be evaluated within the framework of ESA recovery goals.

**What's New:** Additional actions and hatchery reforms benefiting ESA listed fish.

## 6.0 Hatchery RM&E

**Management Questions:** The following are the primary management questions with respect to hatchery actions. Hatchery RM&E actions are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

- Are hatchery improvement programs and actions achieving the expected biological performance targets?
- What is the proportion and origin of hatchery fish within naturally spawning salmon and steelhead populations?
- Can hatchery reforms reduce the deleterious effects of artificial production on listed populations, thereby contributing to a reduction in extinction risk for affected natural populations?
- Can properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations?
- What is the reproductive success of hatchery fish spawning in the wild relative to the reproductive success of wild fish?

See Table 5, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Hatchery RM&E. Additional, more detailed information supporting the identification of Hatchery RM&E Proposed Actions is provided in Appendix 5.

**Performance Measures:** The primary performance measures for hatcheries involve implementation tracking and the qualitative ranking of the expected benefits of proposed actions. The objectives of these actions include:

- Safety-net programs reduce extinction risk for target populations in Snake River sockeye, Snake River spring/summer Chinook, Mid-Columbia River steelhead, Lower Columbia River steelhead, and Columbia River chum salmon ESUs.
- Conservation hatchery programs increase abundance of target populations in Snake River spring/summer Chinook, Snake River fall Chinook, and Upper Columbia steelhead ESUs, thereby reducing the time to recovery.
- High-priority hatchery reform actions, i.e., those needed to address hatchery programs that are considered major limiting factors by NOAA, result in improved abundance, productivity, diversity, and/or spatial structure of target populations.
- Future implementation of additional hatchery reforms identified through Columbia River Hatchery Scientific Review Group's hatchery review process, combined with use of Best Management Practices at FCRPS hatchery facilities, improve abundance, productivity, diversity, and/or spatial structure of target populations, depending on the nature of the reform.

Hatchery action effectiveness research will be used to help confirm and update our expectations of these benefits as new information becomes available.

In addition to these qualitatively rated benefits and performance targets identified above, a more quantitative assessment approach has been included for the benefits associated with improved hatchery management practices. This assessment associates changes in management practices to a change from historic to current reproductive success of hatchery fish spawning in the wild. This change in reproductive success of hatchery fish and the number of hatchery spawning fish over time has been used to estimate a survival improvement for supplemented populations.

Research on the current reproductive success of hatchery fish spawning in the wild will be used to help confirm these estimated benefits and update modeled population effects where needed.

Programmatic performance standards will be developed for Best Management Practices that are being set for various hatcheries based on ongoing regional program reviews.

**Action: Monitor Hatchery Effectiveness**

The Action Agencies will continue to fund selected monitoring and evaluation of the effectiveness of proposed hatchery actions. The evaluation of hatchery projects will be coordinated with the Tributary Habitat monitoring and evaluation program. These actions include:

- *Determine the effect that safety-net and conservation hatchery programs have on the viability and recovery of the targeted populations of salmon and steelhead.*
- *Determine the effect that implemented hatchery reform actions have on the recovery of targeted salmon and steelhead populations.*

**Action: Investigate Hatchery Critical Uncertainties**

The Action Agencies will continue to fund selected research directed at resolving artificial propagation critical uncertainties:

- *Estimate the relative reproductive success of hatchery-origin salmon and steelhead compared to reproductive success of their natural-origin counterparts.*
- *Determine if hatchery reforms reduce the deleterious effects of artificial production on listed populations, thereby contributing to a reduction of extinction risk for the affected natural populations.*
- *Determine if properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations.*

The AA will place a priority on hatchery critical uncertainties research in areas where answers to hatchery management questions are most critical to the success of the PA. Answers to hatchery critical uncertainties are most critical for Upper Columbia River steelhead, Snake River Spring/Summer Chinook, Snake River B-run Steelhead, and Snake Fall Chinook.

## RME Strategy 7: Predator RM&E

**Funding Source(s):** BPA – direct funding; Corps of Engineers O&M and Columbia River Fish Mitigation Program funding.

**Rationale:** Evaluating predator management actions is a key aspect of the FCRPS actions.

**What's New:** Additional actions including RM&E leading to development of a land management plan for avian predators.

## 7.0 Predator RM&E

**Management Questions:** The following are the primary management questions with respect to predation. Predation RM&E actions described in this plan are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

- Are predator programs and actions achieving the expected biological performance targets?
- What are the impacts and consumption rates of major piscivorous, avian, and mammalian predators on juvenile salmonids within the Columbia River Basin?
- What are the distributions, population sizes, and productivity for the major predators within the Columbia River Basin?
- Is there compensation occurring in reaction to predator reduction measures?
- What is the effect of alternative management alternatives/actions used to reduce the impact of predators? What are the most effective management alternatives/actions?

See Table 6, Appendix 1for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Predation RM&E.

**Performance Measures:** Estimates of juvenile fish survival improvements associated with changes in both piscivorous and avian predation have been identified for the periods FY07-09 and for FY10-17 for long term performance targets for predator management. Performance standards have also been set for annual tracking of project implementation projected for the periods FY07-09 and for FY10-17. Research and monitoring on predator – prey relationships, predator exploitation rates and resulting change in annual juvenile fish survival rates will be used to evaluate progress and achievement of expected survival improvements from predation actions.

The following actions address avian, fish, and marine mammal predation in turn.

**Action: Monitor and Evaluate the Caspian Tern Population in the Columbia River Estuary**

The Action Agencies will monitor the tern population in the estuary and its impacts on outmigrating juvenile salmonids, as well as the effectiveness of the Caspian tern management plan.

- *Estimate annual Caspian tern predation rates on juvenile salmonids and the estimated change in juvenile salmonids survival rates.*
- *Determine the size, habitat use, nesting success, and factors limiting the nesting success of the Caspian tern colony on East Sand Island.*
- *Determine diet composition of Caspian terns nesting on East Sand Island.*
- *Detect the formation of tern colonies at other dredged-material disposal sites in the estuary.*
- *Determine the accuracy of tern predation rates on salmonids based on smolt PIT tag recoveries on colony.*
- *Continue ongoing research to detect PIT tags deposited on avian bird colonies in the estuary.*

**Action: Monitor and Evaluate the Double-crested Cormorant Population in the Columbia River Estuary**

The Action Agencies will monitor the cormorant population in the estuary and its impacts on outmigrating juvenile salmonids in an effort to determine if management is warranted and to determine potential management techniques to decrease predation rates.

- *Estimate annual double-crested cormorant predation rates on juvenile salmonids and the estimated change in juvenile salmonids survival rates.*
- *Determine the colony size, habitat use, nesting success and factors limiting nesting success of double-crested cormorants nesting on East Sand Island.*
- *Determine diet composition of cormorants nesting on East Sand Island.*
- *Determine the accuracy of cormorant predation rates on salmonids based on smolt PIT tag recoveries on colony.*
- *Determine the geographic boundaries of the Pacific Coast subspecies of double-crested cormorant so that the size of the population and management unit that includes the East Sand Island cormorant colony can be ascertained.*
- *Determine the potential to use social attraction and habitat improvements to attract double-crested cormorants to alternative nesting locations.*
- *Continue ongoing research to detect PIT tags deposited on avian bird colonies in the estuary.*

**Action: Monitor and Evaluate Inland Avian Predators**

The action agencies will monitor avian predator populations in the Mid-Columbia and evaluate their impacts on outmigrating juvenile salmonids in an effort to determine if management of the colonies is warranted and to determine potential management techniques to decrease predation rates.

- *Determine colony locations, size, and distribution, and habitat use and nesting success of avian predators on Corps owned lands in the Lower Snake and mid-Columbia rivers towards developing a land management plan.*
- *Determine diet composition and consumption of juvenile salmonids by inland avian predators (including terns nesting on Crescent Island and by cormorants nesting on Foundation Island)*
- *Determine the effects of operational strategies on avian predation rates on juvenile salmon*

**Action: Monitoring Related to Marine Mammal Predation**

The Action Agencies will monitor the marine mammal population at Bonneville Dam and its impacts on returning adults, as well as the effectiveness of the management actions to reduce predation rates.

- *Estimate overall sea lion abundance immediately below Bonneville dam.*
- *Monitor the spatial and temporal distribution of sea lion predation attempts and estimate predation rates.*
- *Monitor the effectiveness of deterrent actions (exclusion gates, acoustics, and harassment) and their timing of application on spring runs of anadromous fish passing Bonneville Dam.*

**Action: Monitoring Related to Piscivorous (Fish) Predation**

The Action Agencies will continue to reduce the number of larger, predatory northern pikeminnow throughout the mainstem Columbia and Snake rivers through implementation of the Northern Pikeminnow Management Program.

- *Continue to update and estimate the cumulative benefits of sustained removals of northern pikeminnow since 1990*
- *Continue to evaluate if inter and intra compensation is occurring*
- *Evaluate the benefit of additional removals and resultant increase in exploitation rate's effect on reduction in predator mortality since the 2004 program incentive increase*
- *Develop a study plan to review, evaluate and develop strategies to reduce non-indigenous pisciverous predation*

## RME Strategy 8: RM&E Coordination and Data Management

**Funding Source(s):** BPA – direct funding; Corps appropriations; Bureau appropriations

**Rationale:** Because FCRPS RME is part of the overall RME for recovery of salmon in the Columbia Basin, coordination and data management are tools to make this RME more effective.

## 8.0 RM&E Coordination and Data Management

See Table 7, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for RM&E Coordination and Data Management.

**Action: Coordination**

The Action Agencies will coordinate RM&E activities with other federal, state and tribal agencies, including:

- *Organizing and supporting the COE Anadromous Fish Evaluation Program.*
- *Support and participate in the NPCC Fish and Wildlife Program project planning and review efforts.*
- *Support the standardization and coordination of tagging and monitoring efforts through participation and leadership in the Pacific Northwest Aquatic Monitoring Partnership.*
- *Work with regional monitoring agencies to develop, cooperatively fund and implement standard metrics, business practices and information collection and reporting tools needed to cooperatively track and report on the status of regional fish improvement and fish monitoring projects.*
- *Coordinate the further development and implementation of Hydro, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RM&E components of the Proposed Action through leadership and participation in ongoing collaboration and review processes and workgroups.*

- *Coordinate implementation with other appropriate regional processes. This includes coordination related to statutory provisions for the Federal government (BPA/Council), voluntary coordination among Federal agencies (Federal Caucus), and coordination with regional processes for Federal/non-Federal engagement (TMT, SCT, Pacific Northwest Aquatic Monitoring Program (PNAMP), Northwest Environmental Data-network (NED), etc.).*

**Action: Data Management**

The Action Agencies will ensure that the information obtained under the auspices of the FCRPS RM&E Program is archived in appropriate data management systems. Proposed actions include:

- *Continue to work with regional federal, state and tribal agencies to establish a coordinated and standardized information system network to support the RM&E program and related performance assessments. The coordination of this development will occur primarily through leadership, participation and joint funding support in the Northwest Environmental Data-network (NED) workgroup, the PNAMP coordination group and the RM&E pilot studies in the Wenatchee, John Day, Upper Salmon, and estuary.*
- *Contribute funding for data system components that support the information management needs of individual Hydro, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RM&E .*
- *Participate in NED and PNAMP efforts to develop and implement a regional management strategy for water, fish and habitat data*

## RME Strategy 9: Project Implementation and Compliance Monitoring

**Funding Source(s):** BPA – direct funding; Corps appropriations; Bureau appropriations

**Rationale:** Regular tracking of implementation commitments is essential to accountability.

## 9.0 Project Implementation and Compliance Monitoring

The Action Agencies have identified specific commitments or actions for each of our hydrosystem, estuary/ocean, tributary habitat, hatchery, and predator control strategies, providing clear programmatic level measures for evaluating progress, subject of course to adaptive management. We will update these implementation details in 3 year cycles. Projects will be monitored for implementation of planned deliverables and compliance to performance expectations.

**Action: Implementation and Compliance Monitoring**

- *The Action Agencies will monitor the successful implementation of projects through standard procedures and requirements of contract oversight and management, and review of project deliverables and final reports.*
- *The Action Agencies will maintain BiOp databases to provide fish improvement and monitoring project and action level details for planning and reporting purposes. This*

*approach will provide the most up-to-date information about the status of actions and projects being implemented.*

- *The Action Agencies will use the project level detail contained in the Action Agencies' BiOp databases to track results and assess our progress in meeting programmatic level performance targets. This performance tracking will be reported through annual progress reports and the 2012 and 2015 comprehensive reports.*

# Research Monitoring & Evaluation Project Tables

**Action Agency funded projects that have been identified for implementation during the FY07-FY09 period to meet the Proposed Actions for Research, Monitoring and Evaluations for Hydro (Table 1), Habitat (Table 2), Estuary/Ocean (Table 3), Harvest (Table 4), Hatchery (Table 5), Predation (Table 6), RM&E Coordination and Data Projects (Table 7), and Fish Population Status Monitoring (Table 8).**

**Table 1. Hydro RM&E Projects occurring during the FY07-FY09 Period, Status Monitoring (S), Action Effectiveness (A), and Uncertainties (U).**

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| **Systemwide studies** | | | | |
| *Research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU* (BPA 1991-029-00) –Monitor and evaluate post-release attributes and survival of natural and hatchery juvenile fall Chinook in the Snake River and Hanford Reach of the Columbia River. | This study attempts to inform decisions that will increase FCRPS effectiveness, maximize the growth of wild fall Chinook salmon, increase the survival of wild fall Chinook salmon, reduce the interactions of wild and hatchery fish, and increase understanding of the summer spill program. | X | X | X |
| *Snake River fall Chinook salmon life history investigations* (BPA 2002-032-00) –Investigates the consequences of ocean- and reservoir-type life histories on passage timing, travel rate, survival, and SAR calculations for Snake River fall Chinook salmon. Mechanisms and prevalence of these life histories are explored. | The research goal is to provide fishery managers with an increased understanding of how reservoir water temperature, reservoir water velocity, and migration timing affect juvenile fall Chinook salmon behavior, survival, and life history, to decrease the uncertainty in how the reservoir life history affects estimates of smolt-to-adult return rates of Snake River fall Chinook salmon, and to increase the understanding of when to spill water and transport fish in the Snake River to increase juvenile fall Chinook salmon survival. | X | X | X |
| *Analyze the Persistence and Spatial Dynamics of Snake River Chinook Salmon* (BPA 1999-020-00) – Results will advance current understanding of the relationship between landscape characteristics and the distribution, pattern, and persistence of Chinook salmon. Such information could be key to development of conservation and restoration strategies. | Close-out of previous research | X | | |
| *Lower Snake River Transportation Evaluations* (Corps) – Tagging for wild steelhead and Chinook for lower | Adult returns expected from indexed group of barged fish. Final results from the 2004 evaluation are anticipated and further evaluations are ongoing. | X | X | X |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| Snake River transport evaluations were completed in 2003. Index tagging has been performed from 2004-2007 and an evaluation of weekly SARs will be conducted from 2007-2009. | | X | X | X |
| *Continued PIT-analysis* (Corps) – An historic PIT analysis of transport studies from 1995-2000 will be continued. This research is meant to give insight into how the transportation process could be improved. | Complete an analysis of near shore oceanic and estuarine environmental conditions, the relationship between transport conditions, and hatchery effects. Future updates based on completed adult returns will assist if future actions are warranted. | X | X | X |
| *Mid-Columbia Transport Studies* (Corps) – The Corps released the fourth and final year of Mid-Columbia River fish for a transport evaluation at McNary Dam in 2005. Research from this study is expected to provide operational information on the success of bypassing and spilling spring migrating fish and whether re-initiating spring transport at McNary Dam would be appropriate. | Final year of released fish. | X | X | X |
| | Final year of returned fish (Chinook). | X | X | X |
| | Final year of returned fish (steelhead). | X | X | X |
| | Final reporting | X | X | X |
| *Snake River Fall Chinook Transport Studies* (Corps) – New information suggests that a significant percentage of Snake River fall Chinook adults migrated as yearlings. This raises questions about the significance of summer operations to the fall Chinook population. As a result, a more comprehensive plan will be developed to address the operational needs of Snake River fall Chinook. Future research would help to determine whether transport or in-river passage in the summer is the best management strategy for juvenile Snake River fall Chinook. | Evaluate the juvenile response and adult smolt-to-adult returns (SARs) under full transportation conditions. | X | X | X |
| | Develop comprehensive fall Chinook plan for transport vs. in-river survival. | X | X | X |
| | Implement comprehensive fall Chinook transport vs. inriver study, following installation of RSWs and collection of adequate life history information. | X | X | X |
| | An index group of fish trucked from Lower Granite Dam in September and October has been tagged between 2002-2004. Information gathered is expected to provide information on whether to continue trucking fish from the Lower Snake River in the fall. Adult returns are expected through 2008. | X | X | X |
| *Fish Ladder Temperature Evaluation* (Corps) – Study to define any problems that may exist specific to effects of fish ladder water temperature on adult salmon and steelhead and to determine feasible methods of mitigating any adverse affects. | Phase 2 and 3 reporting. | | X | |
| | Optional - test prototype structure | | X | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *PIT-tag data recovery* (Corps & BPA funding) – The PIT-tag trawler detection system will continue to be operated to collect data in the estuary and estimate system survival to Bonneville Dam tailrace (BPA Project 1993-029-00, cost shared with Corps). The juvenile and adult PIT-tag detection systems will continue to operate and collect passage data at the mainstem dams (BPA Project 1990-080-00). PIT-tag detection will continue on the inland and estuarine islands to estimate avian predation (Corps funded). | 1. Estimate survival for releases of yearling spring/summer Chinook salmon and steelhead (hatchery and wild) through the Snake and lower Columbia Rivers.<br>2. Estimate survival from McNary Dam tailrace to John Day Dam tailrace for subyearling fall Chinook salmon during the summer migration.<br>3. Estimate survival and travel time for subyearling fall Chinook salmon from Pittsburg Landing and Billy Creek on the free-flowing Snake River through the lower Snake River.<br>4. Extend system survival estimates to Bonneville Dam tailrace using PIT tag pair trawl detections.<br>5. Collection and storage of juvenile and adult passage data at all PIT tag detection sites for other future analyses.<br>6. Estimate avian predation rates.<br>7. Estimate avian predation rates for juvenile fish with various migration histories (e.g. transport). | X | X | |
| *Avian Predation Deterrent Program* (Corps) – Study that will focus on gull and other avian predators at each Lower Snake and Columbia River Dam. The study was initiated in 2005 to evaluate the affects of various deterrent methods on gulls and other avian predators. The results of this study will provide the basis for future deterrent methods at the projects. | Evaluate various avian deterrent methods. | | X | |
| | Final report and initiate actions based on results | | X | |
| *Dev Of Systemwide Predator Control for Northern Pikeminnows* (BPA 1990-07-700) –The Northern Pikeminnow Management Program is designed to remove predator-sized northern pikeminnows from the mainstem Columbia. | This program employs a sport reward fishery for northern pikeminnow with a goal of a 10-20% exploitation rate for predatory size fish in order to reduce salmonid predation by up to 50%. This program attempts to evaluate the effectiveness of pikeminnow removals for population analysis and determination of the effect of the program on increase in salmonid survival. | X | X | |
| *Adult passage studies* (Corps) – Complete final summary reports of 1996-2004 radio tagged data (finalized in 2006), including escapement, straying, fallback and passage. | Conduct spawning success evaluations using PIT-tagged fish only. Evaluate new adult PIT detection systems using radio tagged fish (2006, maybe additional year). Develop methodology to measure adult performance standards using PIT data. Investigate development of PIT detection in index tributaries to measure straying | | X | |
| *Installation of Adult PIT-tag Detection Systems* (BPA 2001-003-00) – Provides for procurement of | Install additional adult PIT detection systems at The Dalles dam (North and East ladders). | X | X | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| PIT tag interrogation system electronic components and labor for assembly and installation in adult fish ladders. This project is coordinated with the Corps' *Adult Passive Integrated Transponder (PIT) improvements.* | Modify adult PIT detection systems at John Day dam (North and South ladders). | X | X | X |
| *Adult Temperature Evaluation* (Corps) – Water temperature has the potential to affect the migration behavior of adult salmon (rate of passage, delays, wandering/straying, and survival through the hydrosystem); it also impacts the physiological processes that make spawning successful (egg viability and energy expenditure). | The objective of this study is to determine the effect high water temperatures have on the ability of adult salmonids to migrate to spawning grounds and successfully spawn. Analysis and reporting. | | X | |
| *Adult Fish Transition Pool and Weir Modifications* (Corps) – Radio telemetry studies have indicated that many adult salmon migrating upstream turn around near the transition pool in the adult fishways at the Columbia and Snake River dams. The result is that fish may fall out of the fishway, thereby incurring additional hours of delay in passing the project. Transition pools (the junction of the base of the ladder, the collection channel, and a fishway entrance) have been shown to be an area of delay within the fishway. | Evaluate any warranted modifications | | X | |
| | Final Report for Lower Granite Modifications | | X | |
| *Recondition Wild Steelhead Kelts* -- (BPA Project 2000-017-00) This is an evaluation of kelt steelhead reconditioning and the feasibility of reestablishing this life history strategy that was likely suppressed by the hydrosystem. The program utilizes wild fish that would otherwise become mortalities. | Evaluation of potential kelt steelhead management scenarios including direct release, transport and release, short-term reconditioning and transport; and, long-term reconditioning and release. Evaluate effects of long-term kelt reconditioning on the gamete and progeny viability. Perform experiments to evaluate homing fidelity in first time spawners, reconditioned spawners, and (if feasible) natural repeat spawners from the same spawning populations. | X | X | |
| *Kelt Evaluations* (Corps) – Studies on steelhead kelts have been conducted for several years. The focus of the studies was to enumerate downstream kelt passage and run timing through the Lower Columbia River projects, and to determine passage routes, distribution, and survival. Recent evaluations have concentrated on determining the return rates of kelts with PIT tags for both in-river and transported groups. | Final summary report from PIT-tagged fish. | X | | |
| | Develop action plan, if warranted, to determine if additional measures or studies are needed | X | | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *Turbine Survival Program* (TSP) (Corps) – TSP is focused on measures to improve salmonid survival through turbines which include: a) the development of a long term Biological Index Testing plan, and b) support in completing model and survival studies for the Department of Energy, and c) the development of a process for turbine improvements related to turbine rehabilitation. | Develop scope and costs for a long-term BIT strategy. Continue investigations on the biological assessment of physical model data and bioresponse of fish passing through turbines. Develop detailed John Day BIT strategy. Initiate studies to assess pressure acclimation impacts on fish in the context of past, present, and future TSP studies. Continued participation in regional and national forums as they pertain to fish passage. | X | X | |
| | Further assess the impacts of pressure acclimation impacts on fish. Continue development of Long-Term Bio Index Test Plan. Correlate the effect of fish diversion devices on fish distribution at the turbine runner. Perform internal turbine prototype imaging and pressure history to better define the physical environment and fish passage route. Implement BIT strategy to additional families of turbines. | X | X | |
| | Develop plan for modernization of turbine monitoring and control systems to ensure compliance of rigorous biological criteria for operation of turbines. Apply TSP turbine rehabilitation decision framework to existing rehabilitation plan. | X | X | |
| *Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon Smolts through Snake River Dams* (BPA 2003-041-00) | Continue studies to assess downstream migration through Snake River dams relative to changes in post-Bonneville mortality. | | | X |
| *Delayed Mortality of Juvenile Salmonids* (Corps) – Studies to determine the causes and effects of differential delayed mortality of transported juvenile fish ("D"). | Evaluate sensory system damage, potential alternative barge release strategies optimizing barging density. | X | | X |
| *Pit Tagging Spring/Summer Chin (CSS Study) (BPA 1996-020-00)* - Adult and juvenile PIT tag recovery data are analyzed to compare survival estimates for transported fish of known origin, wild and hatchery transported fish and fish handled and not handled at dams. | This project attempts to estimate SARs and determine transportation/control ratios for several stocks. | X | | |
| *CBFWA Collaborative Systemwide Monitoring and Evaluation Program (BPA 2003-036-00)* CSMEP seeks to undertake additional metadata inventories of Columbia subbasin fish data, expand their strength and weaknesses analyses of this existing data, and broaden their collaborative design of improved M&E methods for the Columbia River Basin. | This project assists with collaborative work plan development, inventories existing data to help answer relevant questions, organizes subsets of data into accessible formats, evaluates the ability to answer questions using existing data, provides a collaborative monitoring design, assists with multi-agency implementation of monitoring programs, and also helps to evaluate new monitoring programs. | X | | X |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *Canada-USA Shelf Salmon Survival Study(BPA 2003-009-00)* -- The primary objective of this research is to determine how the ocean environment and climate affect the production of Columbia River salmon by sampling juvenile salmon and oceanographic data in an area of critical importance to Columbia River salmon. | Assess the effects of climate-induced variability on ocean productivity and coastal ecosystems. Develop reliable models to forecast the marine survival of Columbia River salmon. Document the distribution and of marine invasive species and range expansion of warm water species and their impacts on marine ecosystems. Determine the effects of ocean conditions on the marine survival of Columbia River salmon. Describe the geographic distribution and migration of Columbia River salmon in coastal environments. | | | X |
| *Acoustic Tracking for Survival (BPA 2003-114-00)*-- A large-scale array is being constructed that will allow establishing ocean movements and survival of Columbia R salmon directly for the first time. This proposal describes the application of this technology to several key resource management issues. | This project is tracking smolts in the ocean to resolve how to better manage the Columbia Hydropower System. | | X | X |
| *Pacific Northwest Aquatic Monitoring Partnership-Fish Population Monitoring (FPM)--RME Design and Protocols. Programmatic and Standardized Work Products for PNW and the Columbia Basin (BPA 2007-216-00)* -- This proposal will support four FY 07-09 tasks to standardize RME protocols, indicators, methods and analytical processes. All tasks have been approved by the PNAMP Steering Committee representing 20 Charter Agencies. | Compile, Design & Publish Adult/Juvenile Telemetry. Establish standardized and science-based protocols. Field Testing and Gap Analysis. Standardized Field Manual and Completed Protocols | X | | |
| *New Marking and Monitoring Techniques* (BPA 1983-319-00) – This project's primary focus is on the development of new and improved PIT-tag technology, including tag, transceiver, and antenna developments. | Continue development of small-stream PIT detection with capability of remote location. Continue development of a high-flow and high-Q PIT detection system for the use in spillways or surface passage devices (e.g. RSWs, sluiceways). Complete development of a next generation PIT detection transceiver with numerous additional capabilities. | X | X | X |
| | Complete development of a small-stream PIT detection system with capability of deployment in remote locations. Continue development of various PIT detection systems as needed. | X | | |
| | Continue development of various PIT detection systems as needed. | X | | |
| *System and project survival studies – Development of new juvenile tags.* | Initiate evaluation of existing technologies and regional development of long term goals. | | X | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| The Corps and BPA are evaluating new fish marking techniques that would allow for evaluation of juveniles through the outmigration and as returning adults. This system would allow for juvenile interrogation through all passage routes. | Initiate tag development based on results from 2005 program. | | X | |
| *Below Bonneville Survival Studies* – (Corps) - This project assesses juvenile salmon and steelhead behavior and survival from Bonneville Dam to the mouth of the Columbia River. Objectives include assessing the influence of different FCRPS migration histories on post-FCRPS survival, identifying areas of losses, and evaluating post-Bonneville behavior of both transported and in-river migrating fall Chinook. | Assess behavior and survival of smolts from Bonneville Dam to the mouth of the Columbia River. | X | | X |
| *Smolt Monitoring by Federal and Non-Federal Agencies* (BPA 1987-127-00) – Daily passage data through the mainstem, Snake, Columbia and mid-Columbia Rivers to facilitate fish passage management decisions, including Biological Opinion implementation, is collected daily. Sampling and marking occur at 8 sites of the larger region. | Conduct annual Smolt Monitoring Program at seven mainstem Snake and Columbia River dams, Lewiston Snake River trap, Lower Grande Ronde trap, and White Bird trap on the Salmon River. (Note: Imnaha River trap is another SMP site operated by the Nez Perce Tribe (NPT) under BPA funded project 1997-015-01). Perform PIT tagging of juvenile fish at five hatcheries and upload data files to PSMFC database (USFWS tagging support component). Transmit daily juvenile fish passage, sampling, marking, and other biological and hydrological data to online databases at Fish Passage Center (FPC) and PSMFC for distribution region wide. Participating agencies and organizations prepare and submit annual reports to PSMFC summarizing SMP activities and data collected at each monitoring site for use in compiling FPC annual report. | X | | |
| *Statistical Support for Salmonid Survival Studies* (BPA 1989-107-00) – Develop better measurement tools and study designs to estimate juvenile and adult salmonid survival. Develop statistical methods to determine survival rates and survival relationships. Provide statistical guidance to Columbia Basin investigators. | Develop and refine statistical methods, quantitative tools, and performance measures for the research, monitoring, and evaluation of salmonid life history through the hydrosystem. Also provide statistical support to NMFS to conduct smolt survival and transport studies, providing software engineering support for data analyses, statistical model development for field investigations, and peer review and co-authorship of technical and scientific papers | X | X | X |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *Pit Tagging Wild Chinook* (BPA 1991-028-00) – Collect time series information to examine migrational characteristics of wild ESA-listed Snake River spring/summer Chinook salmon stocks. PIT tag wild Chinook salmon parr annually; and subsequently monitor as parr/smolts at stream traps and river dams. | Determine migration timing and survival differences between and within years for individual and combined populations of wild Snake R sp/su Chinook juveniles at instream PIT-tag monitors and L Granite Dam. Determine parr-to-smolt growth rates for these wild PIT-tagged fish populations, annually, by utilizing the separation-by-code system at Little Goose Dam juvenile fish bypass system. Also, determine relationships between water quality and environmental/climatic factors where wild parr reside and subsequent movements/survival of parr/smolts through downstream instream PIT-tag monitors and at L Granite Dam. | X | | X |
| *Imnaha Smolt Survival and Smolt to Adult Return Rate Quantification* (BPA 1997-015-01) – Quantify juvenile emigrant abundance, determine smolt survival from the Imnaha River to Lower Granite and McNary dams, quantify SARs of wild/natural Chinook salmon at Lower Granite Dam and back to the Imnaha River | Close-out of previous research | X | | |
| *M&E Statistical Support For Life-Cycle Studies* (BPA 1991-051-00) – Develop statistical methods for monitoring and evaluating salmonid recovery plans. Provide added-value analyses and statistical support on regional fisheries issues. Provide smolt migration timing predictions on the internet. | Provide in-season statistical support. Provide real-time run-timing predictions. Provide an annual review of run-timing predictions. Provide statistical analysis of historical tagging data. Provide post-season outmigration estimation. Provide analysis of SARs. Provide sample size software. Provide statistical support for region. Provide statistical consultation. Provide continued statistical evaluation of performance standards to improve decision analysis. | X | X | X |
| *Monitoring and Evaluation of Yearling Snake River Fall Chinook Salmon Outplanted Upstream of Lower Granite Dam* (BPA 1998-010-04) – Monitor and evaluate survival and performance of yearling fall Chinook from Pittsburg Landing, Big Canyon, and Captain John acclimation facilities (BPA Project 1998-010-05) to maximize success of the fall Chinook supplementation program above Lower Granite Dam. | Monitor, evaluate, and compare:<br>• Pre-release and release conditions of yearling hatchery fall Chinook released at the Pittsburg Landing, Big Canyon Creek, and Captain John Rapids acclimation facilities with on-station releases at Lyons Ferry hatchery;<br>• Post-release behavior, migration timing, and survival of yearling fall Chinook released at Pittsburg Landing, Big Canyon Creek, Captain John Rapids, and Lyons Ferry hatchery;<br>• Contribution and distribution of adult returns and smolt-to-adult survivals of yearling fall Chinook released from Pittsburg Landing, Captain John Rapids, Big Canyon Creek, and Lyons Ferry hatchery. | X | | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *Evaluate Factors Limiting Columbia River Gorge Chum Salmon Populations* (BPA 2000-012-00) – Evaluate factors limiting chum salmon production in Hardy Creek, Hamilton Springs, and Columbia River side-channel. | Close-out of previous research | X | | |
| *Evaluate Spawning Of Fall Chinook And Chum Salmon Just Below The Four Lowermost Columbia River Mainstem Dams* (BPA 1999-003-01) – Monitor, protect, and enhance the spawning populations of fall Chinook and chum below Bonneville Dam. Search for evidence of fall Chinook spawning below The Dalles, John Day, and McNary dams. | Continue to conduct spawning ground surveys for fall Chinook and chum in the mainstem Columbia and chum in its tributaries from The Dalles Dam downstream to monitor known spawning areas and identify new locations. Determine on-set, peak, and end of spawning fall Chinook and chum in the mainstem Columbia below Bonneville Dam.<br><br>Continue to refine population estimate methods for fall Chinook and chum spawning in the mainstem Columbia below Bonneville Dam and chum in its tributaries from The Dalles Dam downstream. Continue to refine the total Columbia River chum return estimates. | X | | |
| **Bonneville Dam** | | | | |
| *Project Survival Studies* (Corps) – Initiate once all passage modifications are complete including MGRs, B1 Sluiceway and B2 FGE | Evaluate all juvenile passage routes. | X | X | |
| | Final report. | X | X | |
| | Additional evaluation of spillway passage survival may be necessary as well as model studies to establish powerhouse unit operation priorities. | X | X | |
| *Adult Fallback Analysis* (Corps) – The Corps will complete the analysis of adult fallback and make recommendations on potential improvements for passage. | Final report. | | X | |
| *Bonneville 2 FGE Improvements* (Corps) – The Corps will evaluate the effect of improvements to the screen bypass system at the Bonneville 2nd powerhouse following installation of the modifications of the screen bypass system if needed. | If warranted, evaluate Bonneville 2nd powerhouse FGE with improvements. | | X | |
| *Evaluate the effectiveness of the 1st powerhouse sluiceway* (Corps) – Determine the best survival routes and determine if additional measures for juvenile survival improvements are needed at the 1st powerhouse | Data analysis. | | X | |
| | Final report. | | X | |
| *Post-construction evaluation of sluiceway improvements* | Evaluate sluiceway passage efficiency, forebay behavior, and survival. | | | |
| *Complete installation of First Powerhouse MGRs and conduct a post-construction evaluation.* | Estimate total survival of fish passing through turbines at Powerhouse 1. | | | |
| | Final Report | | | |
| *Evaluate the effects of TDG on emerging chum fry below Bonneville Dam* | Conduct lab and field studies of TDG and effects on chum fry. | | | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| **The Dalles Dam** | | | | |
| *Spillway Survival Improvements* (Corps) | Evaluate dam and route-specific survival, tailrace egress, passage distribution, effects on TDG, and erosion monitoring to determine whether additional spillway improvements are warranted. | | X | |
| | Design and construct additional improvements. | | X | |
| | Spillway improvements post construction testing: Evaluate project, dam, and route specific survival and tailrace egress behavior. | | X | |
| | Final Report | | X | |
| *Sluiceway evaluations* (Corps) | Conduct an evaluation to better understand juvenile salmonid response to hydrodynamic conditions upstream of and at the sluiceway entrances. This will be done using an acoustic camera, ADCP, and CFD model. Conduct a 2nd year evaluation to refine sluice gate operation. This will include a hydroacoustic assessment to determine the improvement of an east and west operation of the sluice gates at The Dalles Dam. | | | |
| | Summary Report | | X | |
| | | | | |
| *Evaluate adult delay and fallback* (Corps) | Evaluate adult delay and fallback with new spill patterns developed with respect to the installation of the spillway training wall. | | | |
| | Final report. | | X | |
| | | | | |
| *Evaluate the behavior of fish in the forebay* (Corps) | Evaluate the behavior of fish in the forebay of The Dalles Dam to determine the feasibility of a physical guidance device for the forebay and assist in design of a device to improve fish passage efficiency. | | | |
| | Final report | | X | |
| **John Day Dam** | | | | |
| *John Day Biological Index Testing* (Corps) – Survival data from 2002-2003 suggest that turbine survival at John Day is much lower than at other FCRPS projects. | Design a test strategy to evaluate best turbine operating geometry for fish. | | | |
| | Conduct direct survival and injury portion of the test strategy. | X | X | |
| | Conduct total survival portion of the strategy | | | |
| | Evaluate and report on metrics, including direct effects of turbine passage on fish injury and survival, total survival for fish passing all routes (route-specific and dam), and tailrace egress times and routes. | X | X | |
| *Survival / Efficiency Study.* Survival studies conducted between 1999 and 2000 indicate high spillway survival, low powerhouse survival, and a clear relationship between tailrace egress and fish survival. Alternatives to reduce powerhouse passage and improve tailrace egress will be investigated, starting in 2008. | Evaluate forebay behavior, fish passage distribution through the dam, tailrace egress, and project, dam and route-specific survival. | | | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| **McNary Dam** | | | | |
| *Survival/Efficiency Study* (Corps) – Project passage studies have been conducted from 2002-2005 under 2004 BiOp conditions. Data will be collected to estimate survival of fish in the lower Snake River and make improvements to the project and/or operations to improve fish survival at this Project. Survival information at McNary is needed to make future decisions regarding spill, operations, and project upgrade 2006-2012. | Continue survival studies. | X | X | |
| | Close-out survival studies. | X | X | |
| | | | | |
| | Survival and forebay approach behavior studies at two different spill levels testing existing FPP pattern vs. a new test spill pattern. | X | X | |
| | Undertake survival and approach behavior studies with TSW's in two spillbays. Examine two spill patterns at 40% project spill during the spring, and both 40% and 60% spill during summer. | X | X | |
| **Ice Harbor Dam** | | | | |
| *Survival/Efficiency Study* (Corps) – 2007 will be the third year of evaluation of the RSW at Ice Harbor Dam. Following analysis of results, a decision will be made on whether further testing is needed to decide on a standard operation. If the one of the two tested scenarios is selected, further testing may not be needed. However, if new scenarios (spill patterns, spill percentages, etc.) are desired, further testing may be required. | RSW Evaluation. Estimate all juvenile passage routes for FPE and survival. | X | X | |
| | Continue survival studies. | X | X | |
| | Final report. | X | X | |
| **Lower Monumental Dam** | | | | |
| *Survival/Efficiency Study* (Corps) – Survival studies at Lower Monumental Dam are needed to assist in future decisions for configuration actions and operations at the project. Future decisions at Lower Monumental include spill optimization, relocation of the bypass outfall, and possibly installation of a training wall between the powerhouse and spillway. | Passage and survival studies. | X | X | |
| | Evaluate project distribution and survival through all passage routes including the RSW. | X | X | |
| **Little Goose Dam** | | | | |
| *Survival/Efficiency Study* (Corps) – Fish survival information at Little Goose is limited. The survival level of fish that pass via spillway, turbines, and bypass system is being collected prior to RSW installation. It is important to collect this data to make informed improvements to the | Continue studies. These actions will require significant baseline/survival information to be attained to assist in making decisions about actions at Little Goose. | X | X | |
| | Survival and passage studies using radio telemetry. | X | X | |
| | Survival and passage studies of all passage routes including spill. This study may include an evaluation of 12 vs. 24-hour spill. | X | X | |

| Project/Action (Hydrosystem RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| Project and/or operations to improve fish survival. The immediate focus is to obtain information to assist in placement of the RSW and to determine its potential effectiveness to pass juvenile migrants. | Complete pre-RSW study efforts. | X | X | |

**Table 2. Tributary Habitat RM&E Projects occurring during the FY07-FY09 Period, Status Monitoring (S), Action Effectiveness Research (A), and Uncertainties Research (U).**

| Project/Action & Agency (Tributary RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *PNAMP Funding* (BPA project no. 2004-002-00) | Coordinate PNAMP workgroups and products | X | X | |
| *PNAMP Fish Population Monitoring Tagging Protocols* - (BPA project no. 2007-216-00) | RME Design and Protocols for fish population monitoring. Programmatic and Standardized Work Products for PNW and the Columbia Basin | X | | |
| *Develop and Implement an Integrated Status and Effectiveness Monitoring Program for Salmonids and their Habitat in Three Pilot Subbasins (BPA 2003-017-00) .* | Develop, as subbasin scale pilot programs, status and trend monitoring efforts for anadromous salmonids and their habitat in the pilot subbasins. | X | | X |
| *Salmon River habitat enhancement M & E* (BPA 1994-050-00) | Maintain habitat improvements and evaluate benefits; monitor salmonid populations and habitat parameters; coordinate land and water stewardship activities; coordinate planning, implementation, monitoring, and evaluation of new improvements and protections. | X | | |
| *Salmonid productivity, escapement, trend, and habitat monitoring in the John Day* (BPA 1998-016-00) | Monitor natural escapement and productivity of John Day River Basin spring chinook and summer steelhead. Estimate SAR, egg-to-smolt survival, smolt abundance, and adult and parr distribution for chinook and SAR and spawner escapement for steelhead. | X | | |
| *John Day salmonid recovery monitoring program (BPA 2002-033-00)* | Update salmonid reproduction goals, compile data to develop predictive models to guide future restoration efforts, compile data that presents historical riparian condition. | X | X | |
| *Okanogan Basin Monitoring and Evaluation Project* (BPA 2003-022-00) | Monitor and evaluate important biological, water quality, and physical habitat indicators for anadromous fish throughout the Okanogan River subbasin to establish a long-term status and trend data set and determine responses from habitat restoration effort | X | | |
| *Indexing carrying capacity of salmonids on the basis of stream temperature - John Day Basin* (USBR RME183.JDB.03.100.02) | Monitor, analyze, evaluate effects of push up dam removal | | X | |
| *Lower Methow tributaries effectiveness monitoring study* (USBR RME183.MET.03.100.05a) | Study the geomorphological, hydrologic, and biological responses to irrigation diversion dam redesign and removal in several tributaries in the Methow River Basin. | | X | |
| *USBR Interagency Agreement with USGS/PNAMP - Fish Protocol Review and Planning* | Hire lead scientist to evaluate and recommend tests required to improve and standardize field protocols for fish sampling. | X | X | X |
| *USBR Interagency Agreement with NOAA - remote sensing techniques.* | NOAA applying remote sensing techniques to identify landscape controls on stream temperatures in the John Day Basin. | X | | |
| *Anadromous Fish Habitat &Passage* (BPA 2000-001-00) | Habitat rehabilitation efforts to decrease sediment loads and improve passage for anadromous steelhead and salmon, with monitoring and evaluation efforts to assess effectiveness of | X | X | |

| | | | | |
|---|---|---|---|---|
| | ongoing activities. | | | |
| *Yakima/Klickitat Fisheries Project- M&E* (BPA 1995-063-25) | Monitoring and evaluation of natural production, harvest, ecological and genetic impacts for spring chinook, fall chinook, and coho fisheries enhancement projects in the Yakima Basin. | X | | |
| *Trout Creek O&M* (BPA 1994-042-00) | Conducting monitoring and evaluation of riparian exclosures, instream habitat improvements, smolt outmigrants population estimates, adult upstream composition and population estimate. | X | X | |
| *Life Studies Of Spring Chinook* (BPA 1992-026-04) | Assess critical habitat, abundance, migration patterns, survival, and alternate life history strategies exhibited by spring Chinook salmon and summer steelhead juveniles from distinct populations in the Grande Ronde River and Imnaha River subbasins. | X | | |
| *Idaho Natural Production Monitoring and Evaluation* (BPA 1991-073-00) | Identifies limiting factors and recommends methods to improve adult-to-smolt and smolt-to-adult survival of chinook salmon and steelhead. Provides long-term monitoring data to determine the effectiveness of recovery actions and population status. | X | X | |

**Table 3. Estuary RM&E Projects occurring during the FY07-FY09 Period, Status Monitoring (S), Action Effectiveness Research (A), and Uncertainties Research (U).**

| Project/Action & Agency (Estuary RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| Casillas et al. 1998-2009, *Survival and growth of juvenile salmonids in the Columbia River plume* (BPA 1998-014-00). | Continue to physically characterize and model the Columbia River plume in the nearshore ocean environment, provide estimates of growth of juvenile Chinook and coho salmon inside and outside the plume, and document the impact of changing ocean productivity on survival and growth rates of juvenile salmonids. | X | | X |
| PNNL, *Estuary/Ocean RME support and Facilitation* (BPA 2002-077-00). | Provide facilitation, coordination and implementation of the federal RME plan for salmonids in the Columbia River estuary through the workings of the Estuary/Ocean Subgroup for RME. | X | X | X |
| CREST et al., *Grays River watersheds* restoration and e*ffectiveness monitoring* (BPA 2003-013-00)[a] | Restore and monitor habitat-forming processes important to enhance chum salmon as well as other declining populations in the Grays River following recommendations developed during the BPA-sponsored Grays River Watershed Assessment. | | X | |
| LCREP et al., *Lower Columbia River/Estuary Ecosystem Monitoring* (BPA 2003-007-00). | Habitat monitoring program to develop protocols, procedures, and indicators for measuring habitat condition for both long term habitat monitoring and restoration project monitoring and evaluation requirements; and a toxic contaminants in sensitive habitat areas, contaminant trends over time, and possible impacts on sensitive species. | X | | X |
| Trudel et al., *Canada-USA Shelf Salmon Survival Study* (BPA 2003-009-00). | Provide a single coast-wide set of data that will allow US and Canadian scientists to begin identifying broad regions of good or poor salmon growth in the ocean, and to begin defining the reasons why growth differs between regions and to establish which specific stocks of salmon remain resident in the areas of poorest growth, and therefore to develop some understanding of why marine survival may differ between different stocks of salmon in the ocean. | | | X |
| Bottom et al. 2003-2009, *Historic Habitat Food Web Link* (BPA 2003-010-00). | Evaluate the role of river flow on habitat opportunities and food web structures for juvenile salmon by comparing historic and current conditions using model simulations and empirically derived food-web linkages. Continue to provide support to both the conceptual and numeric estuary models that will contribute to understanding the physical processes that control or contribute to potential limiting factors for juvenile salmonids. | | X | X |
| Welch et al. 1998-2003, *Ocean survival of juvenile salmonids in the Columbia River plume.* (BPA 2003-114-00). | Develop an ability to allow the assessment of early marine survival and ocean movements for Columbia River salmon stocks. Develop a skeleton acoustic array to demonstrate an approach to tracking movements of individual fish through the river and along the West Coast of North America. | | | X |
| Johnson et al., *Ecology of Juvenile Salmon in Tidal Freshwater in the Vicinity of the Sandy River Delta* (BPA 2005-001-00). | Determine presence through time of yearling subyearling Chinook salmon at the Sandy River delta in the tidal freshwater reach of the Columbia River, assess the feasibility of acoustic telemetry in shallow water, and integrate these results with data from other selected estuary monitoring studies. | X | X | X |
| Ledgerwood et al., *Sampling PIT-tagged juvenile salmonids migrating in the estuary* (Corps BPS-W-00-11) | Detect passive-integrated-transponder (PIT) tagged juvenile salmon in the estuary to allow survival to be partitioned between river and ocean environments. And, assess migration timing to the estuary for yearling Chinook salmon and steelhead | X | | X |

| Project/Action & Agency (Estuary RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| | from tagging operations on the Snake and Columbia Rivers. | | | |
| McComas et al. 2001-2010, *A study to estimate salmonid survival through the Columbia River estuary using acoustic tags* (Corps EST-P-02-01). | Develop an acoustic tag and arrays to estimate survival, residence behavior, and ocean entry timing of salmonids. Assess the life histories and FCRPS passage histories and survival and conduct survival studies, to obtain baseline data on yearling and subyearling Chinook travel time and survival from Bonneville dam to the rivers mouth. | X | X | X |
| Bottom et al. 2001-2007, *Estuarine habitat and juvenile salmon – current and historic linkages in the lower Columbia River and estuary* (Corps EST-P-02-02). | Gain information to further our understanding of how juvenile salmonids use the estuarine environment and what factors effect their overall survival and fitness. This information will be critical to assist in present and future estuary restoration activities. As restoration efforts begin in the estuary and lower river, hypotheses will be formalized and specific studies may continue. | X | | X |
| Muir et al. 2002-2008, *Evaluation of the relationship among time of ocean entry, physical, and biological characteristics of the estuary and plume* (Corps EST-P-02-03). | Assess estuary and near ocean entry timing, and associated physical and biological characteristics, and survival to adult. This project worked to tag and release salmon for four years with the study continuing through the adult recovery of the last group released. The study is currently in the recovery and analysis phase. | | | X |
| Thom et al. 2003-2009, *Evaluating the Cumulative Ecosystem response to Restoration Projects in the Columbia River Estuary* (Corps EST-P-02-04). | Perform research to develop a framework and methodology to measure and evaluate the cumulative effects of habitat restoration actions within the lower Columbia River and estuary. Additionally, the project will develop standard protocols for key monitoring attributes of estuary ecosystem structures, processes, and functions to be implemented at both restoration and reference sites. These protocols have (in draft format) been coordinated throughout the region through LCREP and CREST audiences. The Action Agencies intend to use this multi-year research effort to establish scientific capability to assess whether habitat restoration is having a measurable, cumulative effect on the lower river and estuary, and ultimately contributing to the recovery of ESA listed salmonids in the Columbia Basin. | | X | X |

[a] CREST et al. is listed as a habitat project in BPA's Decision Letter on the FY07-09 F&W Program.

**Table 4. Harvest RM&E Projects occurring during the FY07-FY09 Period, Status Monitoring (S), Action Effectiveness Research (A), and Uncertainties Research (U).**

| Project/Action & Agency (Harvest RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| Technical Advisory Committee (TAC) of US. v Oregon, *PIT tag recoveries in commercial and sport fisheries*, (BPA TBD). | Evaluate the feasibility of obtaining PIT tag recoveries in Zone 6 to determine whether recoveries can help refine estimates of inriver harvest rates, upstream survival rates, and straying rates. | X | | X |
| Confederated Colville Tribes, *Evaluation of Live-Capture, Selective Fishing Gear* (BPA 2007-249-00). | Identify and test live capture selective harvest methods. Identify the catch per unit effort (CPUE) of the target species, Chinook salmon, for each gear and location combination. Evaluate the comparative survival of Chinook captured in these gears and held. Evaluate the immediate survival of target and bycatch captured in these gears. | | X | X |
| Pacific States Marine Fisheries Commission, Washington Dept. of Fish and Wildlife,., *Coded Wire Tag Recoveries* (BPA 1982-013-02, BPA 1982-013-01) | Support coded-wire tagging and coded-wire tag recovery operations that inform survival, straying, and harvest rates of hatchery fish by stock, rearing facility, release treatment, and location (BPA projects 198201302 and 198201301). | X | X | |

**Table 5. Hatchery RM&E Projects occurring during the FY07-FY09 Period, Status Monitoring (S), Action Effectiveness Research (A), and Uncertainties Research (U).**

| Project/Action & Agency (Hatchery RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *Methow River steelhead relative reproductive success study* (New - BPA TBD) | Initiate a study of reproductive success of hatchery-origin steelhead relative to natural-origin steelhead in the Methow River to verify metrics used for gap analysis. | | X | X |
| *Investigate Snake River sockeye salmon smolt mortality between the Stanley Basin and Lower Granite Dam* (New - BPA TBD) | Initiate a radio-tracking study of radio-tagged sockeye smolts between the release sites in the Stanley Basin of Idaho and Lower Granite Dam. The overall objective is to identify the location(s) and potentially the source(s) of the relatively high smolt losses that have been observed during downstream migration in the Salmon and Snake rivers. | | X | X |
| *Umatilla Hatchery M&E [MCR steelhead component]* (BPA 1990-005-00) | Continue monitoring and evaluation related to MCR steelhead safety-net program. | | X | X |
| *Umatilla Basin Natural Production M&E [MCR steelhead component]* – CTUIR (BPA 1990-005-01) | Continue monitoring and evaluation related to MCR steelhead safety-net program. | | X | X |
| *Hood River Production Program M&E [LCR steelhead component]* – ODFW (BPA 1988-053-04) | Continue monitoring and evaluation related to LCR steelhead safety-net program. | | X | X |
| *Hood River Production Program M&E [LCR steelhead component]* – CTWSRO (BPA 1988-053-03) | Continue monitoring and evaluation related to LCR steelhead safety-net program. | | X | X |
| *Grande Ronde Supplementation Lostine River O&M/M&E* (BPA 1998-007-02) | Continue monitoring and evaluation related to Grande Ronde Chinook (Snake River Spring/Summer Chinook) safety-net program. | | X | X |
| *Grande Ronde Supplementation O&M/M&E* (BPA 1998-007-03) | Continue monitoring and evaluation related to Grande Ronde Chinook (Snake River Spring/Summer Chinook) safety-net program. | | X | X |
| *Captive Broodstock Artificial Propagation* (BPA 1998-010-06) | Continue monitoring and evaluation related to Grande Ronde Chinook (Snake River Spring/Summer Chinook) safety-net program. | | X | X |
| *Nez Perce Tribal Hatchery M&E [Snake River fall Chinook component]* (BPA 1983-350-03) | Continue monitoring and evaluation related to Snake River fall Chinook supplementation in the Clearwater Basin. | | X | X |
| *Evaluation of Reproduction of Steelhead* (BPA 2003-050-00) | Continue to evaluate the individual reproductive success of naturally spawning hatchery steelhead relative to that of native wild steelhead using genetic tools and methods. | | | X |
| *Reproduction of Steelhead in Hood River* (BPA 2003-054-00) | Continue estimating the reproductive fitness of traditional and supplementation hatchery stocks relative to that of wild fish. New data to include summer run supplementation stock vs. wild, and effects of mixing 1st generation fish back into hatchery. | | | X |
| *Evaluate Reproductive* | Continue and complete the project. Use genetic analysis of | | | X |

| Project/Action & Agency (Hatchery RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| *Success of Wild and Hatchery Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam* (BPA 2003-060-00) | wild and hatchery-origin Snake River fall Chinook to estimate relative reproductive success. These data will assist assessment of hatchery Chinook effects on productivity and recovery. | | | |
| *Evaluate the Relative Reproductive Success of Reconditioned Kelt Steelhead* (BPA 2003-062-00) | Continue to directly measure the reproductive success of natural-origin, hatchery origin, and reconditioned kelt steelhead in natural streams. The study will yield quantitative data replicated geographically and temporally. | | | X |
| *Idaho Supplementation Studies* (BPA 1989-098-00) | Continue the evaluation of supplementation as a recovery/restoration strategy for spring/summer Chinook salmon in Idaho. The project is a multi-agency effort, covering 30 streams throughout the Salmon and Clearwater subbasins. | | X | X |
| *Genetic Monitoring of Snake River Chinook Salmon and Steelhead* (BPA 1989-096-00) | This genetic monitoring program is designed to evaluate the effects of hatchery-reared fish on natural and wild populations of spring/summer Chinook salmon and steelhead in the Snake River Basin. This study has two major research components, gene frequency monitoring over time and space and a direct examination of reproductive success through pedigree reconstruction. Project includes research on relative reproductive success of hatchery-origin steelhead in Little Sheep Creek and hatchery-origin spring/summer Chinook in the Lostine River and Catherine Creek (where the hatchery-origin fish are adult offspring of captive broodstock program parents). | | X | X |
| *Snake River Sockeye Salmon Habitat and Limnological Monitoring* (BPA 1991-071-00) | Monitor and enhance (if necessary) rearing conditions for juvenile sockeye salmon in Stanley Basin, ID, nursery lakes. Investigate competition, growth rates, and survival for progeny released from the Snake River sockeye captive broodstock program. | | X | X |
| *Research to Advance Hatchery Reform, Including Captive Broodstocks* (BPA 1993-056-00) | This project will provide guidance on management of Columbia River Basin hatcheries, including captive broodstocks. Research will focus on developing methods to improve broodstock management and fish quality and reduce negative ecological interactions. | | | X |
| *YKFP – Klickitat Subbasin Monitoring and Evaluation* (BPA 1995-063-35) | The project will continue to test whether new artificial production techniques, coupled with strategic habitat actions, can be used to increase harvest and natural production of Yakima Basin spring Chinook, fall Chinook, coho salmon, and steelhead while maintaining the long-term genetic fitness of the population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits. The project is designed to provide knowledge about supplementation so that it may be used to mitigate effects on anadromous fisheries throughout the Columbia River Basin. | | | X |
| *Develop Progeny Marker for Salmonids to Evaluate Supplementation* (BPA 2002-030-00 – a project in the Agreement on 2007 FCRPS | The project will assess the relative reproductive success of Umatilla Hatchery summer steelhead using a pedigree analysis and a laboratory-tested strontium progeny marker injection and will compare the power and accuracy of the two techniques. | | X | X |

| Project/Action & Agency (Hatchery RM&E) | Objective/Deliverable | S | A | U |
|---|---|---|---|---|
| Fish Operations) | | | | |
| *Growth Modulation in Salmon Supplementation* (BPA 2002-031-00) | This project assesses and develops methods to control high rates of early male maturation in salmon supplementation programs. Reductions in early male maturation will increase smolt to adult survival and reduce genetic and ecological impacts. | | | X |
| *Monitoring the Reproductive Success of Naturally Spawning Hatchery and Natural Spring Chinook Salmon in the Wenatchee Watershed* (BPA 2003-039-00) | Continue quantitative evaluation of the relative reproductive success and survival of naturally spawning hatchery and natural origin spring Chinook salmon in the Wenatchee River watershed above Tumwater Dam. | | | X |

**Table 6. Predator RM&E Projects occurring during the FY07-FY09 Period, Status Monitoring (S), Action Effectiveness Research (A), and Uncertainties Research (U).**

| Project/Action & Agency (Predator RM&E) | 2007-2009 Deliverable/Objective | S | A | U |
|---|---|---|---|---|
| *Northern Pikeminnow Management Program* (BPA 1990-077-00) | Continue and improve ongoing monitoring and evaluation program component of NPMP. Evaluate effectiveness of any other non-indigenous predator management program if tested and implemented. | X | X | |
| *Avian Predation on Juvenile Salmonids in the Lower Columbia River* (BPA 1997-024-00) | Continue the RM&E program to determine the effects of tern redistribution on colony size, annual reproductive success, and annual consumption levels of juvenile salmonids by Caspian terns remaining on East Sand Island. Continue and expand research on double-crested cormorants to determine population status, distribution, productivity, diet composition, and management issues. | X | X | X |
| *Mid Columbia Avian Predation Monitoring* (Corps) – Continuation of monitoring of avian predators on Corps owned lands in the mid Columbia River towards supporting a management program aimed at improving juvenile salmonid survival. | Continuation of monitoring of avian activity on Corps owned lands. Key elements will include monitoring Crescent and Foundation Islands towards understanding the numbers of salmonids taken by avian predators. | X | X | |

| Project/Action & Agency (Predator RM&E) | 2007-2009 Deliverable/Objective | S | A | U |
|---|---|---|---|---|
| *Pinniped predation on adult Chinook salmon (Corps)* | Continue monitoring to estimate predation rates by pinnipeds on adult salmon immediately below Bonneville Dam. This effort will also identify individual animals, assess the effectiveness of acoustic deterrent methods, assess hazing in the fishways, and the potential impacts of sea lion excluder devices on salmon and pinnipeds at Bonneville Dam. | X | X | |

**Table 7. RM&E Coordination and Data Management Projects occurring during the FY07-FY09 Period.**

| Project/Action & Agency (Coordination and Data) | 2007-2009 Deliverable/Objective |
|---|---|
| *Develop and Implement an Integrated Status and Effectiveness Monitoring Program* (BPA 2003-017-00) | Coordinate monitoring approaches and protocols with other regional entities across all pilot study areas. Develop standardized monitoring protocol tool, spatial (GIS) database, and tabular database (with GIS links). Coordinate across all pilot study areas. |
| *PNAMP Funding* (BPA project no. 2004-002-00) | Coordinate PNAMP workgroups and products |
| *PNAMP Fish Population Monitoring Tagging Protocols* - (BPA project no. 2007-216-00) | RME Design and Protocols for fish population monitoring. Programmatic and Standardized Work Products for PNW and the Columbia Basin |
| *Streamnet (CIS/NED)* (BPA project no. 198810804) | Regional coordinated information system for archiving fish and habitat data. |
| *Technical Management Team Support* (BPA 1996-019-00) | Hydrosystem survival and fish passage information |

**Table 8. Fish Population Status Monitoring Project occurring during the FY07-FY09 Period. While BPA currently provides regional support for these fish population status data, all of these projects are under review for monitoring efficiencies and prioritization of RM&E efforts and there scope of work and/or funding levels are subject to change in FY08 and FY09.**

| Project/Action & Agency (Fish Population Status) | 2007-2009 Deliverable/Objective |
|---|---|
| *Nez Perce Tribal Hatchery RM&E* (BPA1983-350-03) | Fish Population Data |
| *Umatilla Fish Passage Operations* (BPA 1988-022-00) | Fish Population Data |
| *Hood River Production M&E-ODFW* (BPA 1988-053-04) | Fish Population Data |
| *Hood River Production M&E-Warm Springs* (BPA 1988-053-03) | Fish Population Data |
| *Salmon Studies ID Rivers IDFG* (BPA 1989-098-00) | Fish Population Data |
| *Salmon Studies ID Rivers USFWS* (BPA 1989-098-01) | Fish Population Data |
| *Salmon Studies ID Rivers Nez Perce Tribe* (BPA 1989-098-02) | Fish Population Data |

| | |
|---|---|
| *Salmon Studies ID Rivers Shoshone-Bannock Tribe* (BPA 1989-098-03) | Fish Population Data |
| *Umatilla Basin Nat Prod M*&E (BPA 1990-005-01)<br>*Idaho Steelhead M&E Studies* (BPA 1990-055-00) | Fish Population Data |
| *Life Studies Of Spring Chinook* (BPA 1992-026-04) | Fish Population Data |
| *Trout Creek O&M* (BPA 1994-042-00) | Fish Population Data |
| *Yakima/Klickitat Fisheries Project- M&E* (BPA 1995-063-25) | Fish Population Data |
| *Johnson Creek Artificial Propagation* (BPA 1996-043-00) | Fish Population Data |
| *Listed Stock Adult Escapement* (BPA 1997-030-00) | Fish Population Data |
| *Grande Ronde Sp Chinook-ODFW* (BPA 1998-007-04) | Fish Population Data |
| *M&E Yearling Snake R. Fall Ch* (BPA 1998-010-03) | Fish Population Data |
| *M&E Snake R. Fall Ch Spawning* (BPA 1998-010-04) | Fish Population Data |
| *Captive Broodstock Artificial Propagation* (BPA 1998-010-06) | Fish Population Data |
| *Salmonid productivity, escapement, trend, and habitat monitoring in the John Day* (BPA 1998-016-00) | Fish Population Data |
| *Anadromous Fish Habitat &Passage* (BPA 2000-001-00) | Fish Population Data |
| *Tucannon River Spring Ch Captive Broodstock Program* (BPA 2000-019-00 | Fish Population Data |
| *Walla Walla Subbasin Collaborative Salmonid Monitoring & Evaluation Project* (BPA 2000-039-00) | Fish Population Data |
| *Assess Salmonids Asotin Cr Watershed* (BPA 2002-053-00) | Fish Population Data |
| *Integrated Status and Effectiveness Monitoring Program* (BPA 2003-017-00) | Fish Population Data |
| *Okanogan Basin Monitoring and Evaluation Project* (BPA 2003-022-00) | Fish Population Data |
| *Monitor Reproduction in the Wenatchee Watershed* (BPA 2003-039-00) | Fish Population Data |
| *Evaluate Reproductive Success Snake R Fall Ch* (BPA 2003-060-00) | Fish Population Data |

*This is not a final federal agency product. Rather, it is a pre-decisional document prepared by the Action Agencies that reflects present understandings of currently available information and analyses, and of the progression of discussions with the sovereigns in the collaborative process. Revisions and refinements are to be expected based on further discussions with the sovereigns over new and modified proposed federal actions upon which the action agencies will ultimately consult. Finally, the information in this product does not constitute an analysis of whether the identified measures would or would not jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Furthermore, this document does not in any way interpret or apply the regulatory definitions of the statutory phrases "jeopardize the continued existence of" and "destruction or adverse modification."*

# Hydro Research, Monitoring and Evaluation Proposed Action

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# Introduction

This Appendix to the Hydro RM&E PA provides some additional details regarding RM&E actions that will be implemented to answer key management questions regarding the achievement of hydro fish passage performance standards/targets, identification and understanding of hydro related limiting factors, and the effectiveness of hydro actions. Research and monitoring actions, along with procedures for tracking implementation of hydro actions, coordination of these research and monitoring actions with regional agencies, and management of data. See Table 1, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Hydro RM&E.

# Management Questions

The following are the primary management questions with respect to FCRPS hydro passage actions. Hydro RM&E actions described in this section are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

- Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets?
- Is each project in the hydropower system safely and efficiently passing adult and juvenile migrants?
- What are the most effective configurations and operations for achieving desired performance targets in the FCRPS?
- What is the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville?
- Under what conditions does in-river passage provide greater smolt-to-adult return rates than transport?

The Hydro-System RME Plan identifies actions addressing these management questions using one or more of the following types of RM&E:

- Status Monitoring – Statistically designed monitoring of fish and/or wildlife population and/or environmental conditions (i.e. watershed conditions) to assess the current status or change (trend) over time. This is sometimes referred to as an observational study.
- Action Effectiveness Research – research to determine the effects of an action or suite of actions on fish survival, productivity and/or habitat conditions. This is a manipulative experiment that statistically assesses the effect of a treatment (action) condition relative to a control or reference condition
- Uncertainties Research – research to resolve scientific uncertainties regarding the relationships between fish or wildlife health, population performance (abundance, survival, productivity, distribution, diversity), habitat conditions, life history and/or genetic conditions (e.g. the existence and causes of delayed mortality, hatchery spawner reproductive success relative to wild populations, etc.). This is a manipulative experiment where variables are manipulated to infer or

demonstrate cause and affect relationships using statistical-designed hypothesis testing.

- Project Implementation and Compliance Monitoring – monitoring the execution and outcomes of projects to determine whether projects were carried out as planned.

# Performance Measures, Standards and Targets

The Action Agencies have identified measures that will be monitored to assess performance standards (benchmarks) and performance targets (longer term goals) and to inform adaptive management actions. We will be monitoring two aspects of performance: 1) Programmatic and 2) Biological and Environmental. Programmatic performance will be tracked through project implementation and compliance monitoring. Biological and Environmental performance measures are tracked and evaluated through status monitoring, action effectiveness research and critical uncertainty research in combination with existing and developing quantitative models.

Performance standards will be monitored to insure accountability and adherence to proposed actions. Performance targets will be evaluated over longer time periods as new information and learning is applied through analytical models. Targets allow us to check for progress toward expected life stage survival improvements and trends in ESU or population performance. Performance targets inform longer term adaptive management decisions and prioritization of options across populations with different relative needs. See the Accountability for Results and Risk Section of the PA for more information on performance standards, targets and contingencies.

The biological and environmental performance measures for hydro are juvenile and adult system level survival, juvenile dam passage survival, proportion of juveniles transported, fish and spillway passage efficiency, forebay behavior, tailrace egress and spill, discharge, and water quality at fish passage projects. Performance standards have been set for average juvenile dam survival for run-of-river spring and summer migrants and adult hydro system survival. The expected increase in total juvenile system survival associated with the Hydro proposed actions has been set as a long term performance target for each ESU.

- **Adult Survival**

For adult fish, we have largely achieved or exceeded the performance standard identified in the 2000 BiOp (Ruff Memo 6/29/04 to Brian Brown). Because we do expect the proposed operation to maintain or improve adult passage survival, we will continue that operation and monitor adult passage. We will periodically assess adult survival through the hydrosystem to assess this performance standard and ensure that adult passage survival remains high. This assessment will be based on ESU specific reach survival estimates applied as a rolling 5 year average. Care must also be taken to consider estimates of harvest and stray rates, so that this are separated out from hydro survivals. We are pursuing improvements in harvest estimating techniques to reduce this uncertainty.

Consistent with our adaptive management approach, we will adjust our actions as warranted to ensure implementation of an effective and efficient program for adult migrants. We will continue to report on adult hydrosystem survival in our annual and cumulative progress reports.

- **Juvenile System Survival**

In the biological analyses, we will have estimated the expected juvenile fish survival benefits that are associated with our proposed hydrosystem improvement actions from 2007-2017. We have also displayed recent hydro improvements through 2004, and base or historical hydro passage survivals. These estimates use a 50 year hydrologic record to capture the full range of possible survival conditions and the average over time using the COMPASS model. The Action Agencies propose to use a long term performance target equal to the relative improvement in average survival form our 2007-2017 actions relative to 2004 base conditions. We will report updated juvenile survival improvements relative to this target in 2012 and 2015.

**2012**. For yearling and subyearling Chinook and steelhead, the Action Agencies 2012 comprehensive evaluation will report estimates of average system survival (operations and configurations level) relative to 2004 base level survival conditions. These estimates will be based on the most recent fish passage research applied within the COMPASS passage model, calibrated and validated by recent years' empirical survival data. To account for varying water conditions, the model will use the full 50 year hydrologic record for both the current and 2004 survival estimates (the same procedure used in estimating the hydro survival benefits in the biological analyses).

**2015**. The Action Agencies 2015 comprehensive evaluation and progress report will use the same approach as in 2012. The estimates will be updated with additional research, empirical survival data, and any new operations or configurations present in 2015.

Ongoing smolt monitoring at the dams and through river reaches will be the primary sources of data to inform the COMPASS modeling estimates. It is not practical to attempt field measurements of juvenile fish survival for each stock migrating each year.

We may use surrogates as indicators for some ESUs. For example, estimated survival of a composite of Snake River stocks in the lower Columbia could serve as a surrogate to represent the survival of mid- and lower Columbia River stock survival through the same reach (e.g., McNary to Bonneville). However, we are increasing the smolt monitoring efforts for Upper Columbia Chinook and steelhead, and potentially for Snake River sockeye, in order to have more specific information for these populations in the future.

- **Juvenile Dam Passage Survival**

The Action Agencies propose specific performance standards of 95% average dam survival for spring migrating fish and 93% average dam survival for summer migrating fish, with averaging/tradeoffs allowed between dams. Any survival averaging or tradeoffs between dams may occur amongst the Snake River dams or amongst the lower Columbia River dams, but not between Snake and Columbia River dams.

One mechanism for adaptive management to improve performance, when necessary, will be the Configuration and Operation Plans (COP(s)) that the Corps prepares to evaluate

and develop hydrosystem project improvements. The Corps has prepared COPs that lead to improvements including surface passage (e.g., RSWs) and other dam passage improvements at the Corps projects. A COP is being/has been developed for each dam that will recommend the ultimate configuration and operation for that project. Each COP will be/is developed in close coordination with the Region at the technical level. The COP considers alternatives and performance standards, and several other components as described in the Draft Snake and Columbia River Surface Passage Strategy prepared by the Corps in July 2005. Following installation of dam passage improvements, an evaluation will be conducted to determine the success of the action in meeting the performance standard. If the standard is not met, the Corps will update the COP working within the regional process to determine additional potential actions.

# Hydro Status Monitoring

## Biological Monitoring

***Monitor and Evaluate Fish Performance in the FCRPS***

The Action Agencies will monitor biological responses and/or environmental attributes, and report these estimates on an annual basis. These proposed actions include:

- *Monitor and evaluate juvenile salmonid dam survival rates for a subset of FCRPS projects.*
- *Monitor and evaluate juvenile salmonid system survival through the FCRPS, including estimates of differential post-Bonneville survival of transported fish relative to in-river fish (D) as needed.*
- *Monitor and evaluate adult salmonid system survival upstream through the FCRPS.*
- *Provide additional PIT tag marking of Upper Columbia populations to provide ESU specific estimates of juvenile and adult survival through the Federal mainstem dams.*
- *Assess the feasibility of PIT tag marking of Snake River sockeye for specific survival tracking of this ESU through the FCRPS.*
- *Develop an Action Plan for conducting hydro status monitoring (analytical approaches, tagging needs, methods and protocols) in ongoing collaboration with the state and federal fishery agencies and tribes. This will be done in coordination with status monitoring needs and strategies being developed for estuary/ocean, habitat, hatcheries, and harvest.*

**Juvenile Dam Passage Survival**

This measure will reflect the average passage survival across all dams, incorporating the effects of the passage route and the immediate tailrace, but not the full reservoir effects. We propose that it be empirically estimated with precision of approximately +/- 3% using route-specific survival estimating techniques, such as radio tag or acoustic tag studies. Dam survival standards will apply to Snake River and Upper Columbia River ESUs. The

data are insufficient for developing stock-specific standards. This measure is averaged such that if one dam is estimated to provide a low survival relative to the target, it can be offset by another dam providing higher survival so long as both dams generally pass the same ESUs. For instance low survival at Little Goose may be offset by high survival at Lower Granite since the same ESUs tend to pass both dams. However, low survival at The Dalles may not be offset by high survival at Ice Harbor since The Dalles passes ESUs from the mid- and lower-Columbia that do not pass through Ice Harbor. Therefore, while dam survival averages for most of the Snake River stocks will incorporate eight projects, the upper Columbia stocks will only incorporate the four Columbia River FCRPS projects in the average.

Since it is not feasible to evaluate dam survival for all ESUs at all eight mainstem dams each year, the field studies to assess progress toward meeting this dam survival standard will be completed according to the following guidelines. A technical team of regional representatives will meet to discuss whether any of the dams are already meeting the dam survival. If any of them are, there would be no immediate requirement for a field study to estimate current performance relative to the dam survival standard. For those dams not currently believed to be meeting the standard, a field study of dam survival would be performed after survival improvements have been implemented. If dam survival estimates exceed the standard in two separate years (variability associated with the estimates may dictate a longer timeframe), the standard would be met for that dam. For all dams, once they are determined to be meeting the dam survival standard, a periodic verification field study would be performed once every five years.

**Juvenile System Survival**

In the biological analyses, we estimated the expected juvenile fish survival through the hydrosystem (system survival) that are associated with the hydrosystem actions, and the associated improvement in survival relative to the 2004 base level. The Action Agencies will use these performance expectations relative to 2004 expectations as a basis for longer term performance tracking (a system survival performance target).

In 2012 and 2015, the Action Agencies comprehensive evaluations will present juvenile survival estimates for yearling Chinook and steelhead, and Subyearling Chinook. The report will include estimates of system survival compared to 2004 survival conditions. These estimates will be based on the most recent fish passage research as updated and reflected in the passage model. For example, the model will be calibrated and validated using the most up to date empirical survival data. To account for varying water conditions, the model will use the full 50 year hydrologic record for both the current and 2004 survival estimates (the same procedure used in estimating the benefit of the proposed hydro actions).

To support this model-based performance tracking, the Action Agencies will continue to fund and implement studies concerning dam passage survival, river reach survival, and transportation studies. It is not practical to attempt field measurements of juvenile fish survival for each stock migrating each year. Therefore, we may use surrogates as

indicators for some ESUs. For example, estimated survival of a composite of Snake River stocks in the Columbia below McNary could serve as a surrogate to represent the survival of mid Columbia River populations through the same reach (e.g., McNary to Bonneville). We will continue to collaborate with the regional fish management agencies on the prioritization of available funding and the development/implementation of these survival studies, including the identification of fish tagging needs. Several monitoring requirements will rely on PIT tagged fish entering the FCRPS. Input received from Oregon and CRITFC within the RM&E collaboration group has identified a number of candidate stocks, with proposed sample sizes, that could be PIT tagged and used to satisfy FCRPS monitoring needs. This provides a good starting point, and the AA will work with the fishery agencies to refine the scope of the and needs of the PIT-tagging effort.

**Adult Fish Passage Survival**

The purpose of this performance measure is to track and confirm that the current high levels of adult survival are maintained. The performance measure will be based on PIT tag estimates, with adjustments for estimated harvest rates and stray rates. The existing adult PIT detection system will be used to estimate survival from Bonneville Dam to the most upstream federal dam in the fish's migration path (i.e. to Lower Granite Dam for Snake River ESUs and to McNary Dam for Upper Columbia ESUs). Straying estimates will be based on historical information obtained by Corps-funded radio tag studies (University of Idaho Technical Report 2005-5). Harvest estimates for each year will be based on US-v-Oregon's Technical Advisory Committee (TAC) information. The adult survival measure will take into account fallback and delay effects, in so much as they affect PIT detection survival estimates. Jacks will not be included in the measure and assessment.

***Issues Regarding Performance Indices and Related Matters:***

**Adult Survival Indices-**

In recent years, both radio-tagged and PIT-tagged adults have been used to estimate adult passage survival from Bonneville Dam to their exit point from the FCRPS. Future monitoring efforts will rely on using returning fish that were PIT-tagged as juveniles. Part of the challenge accompanying this approach, is to account for tributary turnoff, straying, fallback and inriver harvest removals en route from Bonneville Dam to the uppermost dam particular to the ESU in question. An Action Plan for Status Monitoring that describes methods and procedures for accomplishing this is proposed to be developed in ongoing collaboration with the state and federal fishery agencies and tribes in coordination with status monitoring needs for estuary/ocean, habitat, hatcheries, and harvest. Although PIT tagged jack salmon will not be included in the annual calculations of system survival, the data will be reported.

**Sampling Units –**

Selecting appropriate biological sampling units determines the demographic resolution for indexing performance. These can be defined at the species level, the ESU component, or populations thereof. Ideally information specific to individual populations is desirable, since some populations may respond differently to a similar hydro-experience. Unfortunately, attaining this ideal situation has proved to be impractical for a variety of reasons. The term environmental sampling unit refers to the geographic bounds over which fish performance is measured. With respect to the FCRPS for juveniles, this extends from the point where an index ESU or population (biological sampling unit) enters the system to some short distance downstream from Bonneville Dam. For adults it is the same, but in reverse. Herein is a brief description.

*Spring Migrants* – Currently, a complex of juvenile wild and hatchery stocks are PIT tagged each year and form a composite index group to monitor passage related survival of juvenile Snake River Spring/summer Chinook and steelhead through the FCRPS. This composite group forms the basis for existing inriver and total system survival estimates. This is not expected to change in the future, but it is not clear exactly what the tagging scheme will be in the future Furthermore, there is a need to continue tributary tagging at current levels, or greater.

In the Upper Columbia, opportunities to PIT tag wild fish are more limited and long-term tagging of hatchery stocks in suitable numbers has not occurred. Thus, too few fish have been available to obtain useful estimates through the FCRPS on a regular basis. As a consequence, managers have relied on performance estimates obtained for Snake River fish migrating through the lower Columbia River to represent upper and mid-Columbia ESUs. To better assess the survival of upper Columbia ESUs, the AA will be implementing additional tagging of these fish based on a collaborative review of the tagging needed assess performance standards.

*Snake River Fall Chinook* – Presently, no acceptable method exists to adequately monitor survival of juvenile fall Chinook through the FCRPS. This poses a severe limitation for monitoring and evaluating the performance of this ESU as they migrate through the FCRPS. This issue is receiving attention and will continue to be addressed within ongoing RM&E collaboration processes and the COMPASS modeling forum.

*Adult Salmonids* – Annual system survival monitoring of adults will rely on returning adults previously PIT tagged as juveniles while in their natal habitat (tributary or hatchery). If the stock complement of fish being tagged differs much from historical efforts, differences in harvest or stray rates may emerge. Tagging plans and final assessments will need to be sensitive to this point.

*Dam Survival*- To monitor dam survival of juveniles, run-of-river fish will form the sampling unit. These fish will be obtained onsite or near the dam of interest. It may include a blend of hatchery and wild fish passing each location. Specific experimental designs and analytical frameworks will be described in an Action Plan that is proposed to be developed in ongoing collaboration with the state and federal fishery agencies and

tribes in coordination with status monitoring needs for estuary/ocean, habitat, hatcheries, and harvest .

**PIT-Tagging Requirements-**

To obtain useful estimates of life stage survival at the population or wild ESU level, adequate numbers of naturally produced fish need to be PIT-tagged. The experience in the Snake River over the last decade has shown that collecting and tagging enough naturally produced fish to represent the spring/summer Chinook and steelhead ESUs, has not been possible. As a consequence, fishery managers have relied on hatchery fish to augment the sample sizes to represent the performance of those ESUs as they migrate through the FCRPS. NOAA investigators have determined that hatchery fish are an adequate surrogate for indexing the performance of the wild ESUs that migrate during the spring.

Importantly, NOAA has relied on other studies to produce tagged fish that can opportunistically be used for this monitoring, e.g. CSS and wild stock tagging in tributaries. Some of those tagged fish serve several purposes as evidenced here. Regionally there is a need to coordinate such tagging across the 4-Hs. As noted previously, ODFW and CRITFC input to the remand collaboration process has identified a number of candidate stocks, with proposed sample sizes, that could be PIT tagged. This provides an excellent starting point, and the AA will work with the fishery agencies to refine the needed PIT-tagging effort and coordinate these hydro tagging needs with other non-hydro tagging and monitoring.

***Projects Contributing to Status Monitoring***

Appendix 1, Table 1 identifies those projects funded by the COE and BPA that contribute to status monitoring efforts called for in this plan.

***Monitoring Juvenile Migration & Fish Condition***

**BPA Fish & Wildlife Program-**

Smolt monitoring tracks various performance indices (e.g. travel time), and fish condition at dams in the FCRPS, as well as projects and trap sites upstream from the FCRPS. PIT tagging efforts associated with the current smolt monitoring program have provided some of the index fish used by NOAA and others in estimating smolt system survival. Some of those tagged fish have come from the Comparative Survival Study. A similar tagging effort will provide the PIT tag numbers necessary for adequate passage survival status monitoring. The intent is to use this pool of tags to monitor both population level survival (SAR) and juvenile system survival. The AA agree with this approach and will collaborate with those parties and other fishery agencies to finalize stock coverage and sample sizes.

**Corps Requirements-**

The Corps requires a program for sampling and monitoring juvenile fish for two primary purposes. The first is to determine if a juvenile fish facility is operating appropriately. Secondly, there is a need to acquire basic information as part of the juvenile fish transportation program. Those estimates include hourly and daily species composition, as well as the number and size frequency of fish collected. Third, there is a need to sample and collect fish for assorted action effectiveness research projects.

***Facility Operation -*** When operating the juvenile fish facilities, there is the potential for fish injury to occur when screens become plugged, orifices become blocked by tree branches, or tumbleweeds get caught on the trashracks, etc… Because of this, some level of fish condition sampling is required to determine if the facility is operating as designed. When not transporting, as at Ice Harbor Dam, sampling for this purpose occurs 2 days a week. This facility operates in primary bypass mode continuously during the spring and has the highest survival of any screened bypass system on the river. With the incorporation of a delayed start of the juvenile fish transportation program at Snake River projects in 2004, the Corps Fish Passage Plan was revised to reflect periodic sampling at Lower Monumental and Little Goose prior to the initiation of transport. Everyday sampling for the BPA funded smolt monitoring is expected to continue at Lower Granite Dam, but is more than what the Corps needs for managing the facilities. Sampling is also required at McNary, John Day and Bonneville dams.

***Transport Program-***When transporting, the Corps must estimate hourly and daily fish collection for managing the juvenile fish transportation program. This sampling is typically a very small proportion of the daily collection and is essential for determining the appropriate loading of raceways, barges, and trucks. Therefore, whenever transporting at a project, daily sampling will be conducted to facilitate the transportation process.

***Research Program*** – When performing Action Effectiveness Research (e.g. RSW effectiveness, etc…), sampling at the hydropower facility is required to obtain fish for study. As a result, to capture fish of a specific species or run type, sampling of additional fish is often required, and monitoring of the type of fish collected is required. This research is performed at a variety of projects across a variety of time frames and can only be planned on a year to year basis.

***Monitoring Adult Migration & Fish Condition***

**COE Program**

Monitoring adult passage counts is a cornerstone monitoring activity that must be performed on an annual basis. Adult fish counting is typically performed 16 hours per day, during daylight hours, by either video or visual counting methods, at all of the Corps projects that pass fish (Technique is outlined in the Annual Fish Passage Plan). Adult fish counting will continue at a minimum on the following schedule:

| Dam | Duration of Operation | Duration of Counting | Hours of Count |
|---|---|---|---|
| Bonneville | January 1 - December 31 | January 1 - December 31 | 04:00 - 20:00 |
| The Dalles | February 20 – December 7 | February 20 – December 7 | 04:00 - 20:00 |
| John Day | February 20 – December 7 | February 20 – December 7 | 04:00 - 20:00 |
| McNary | March 1 – December 31 | March 1 – December 31 | 04:00 - 20:00 |
| Ice Harbor | March 1 – December 31 | March 1 – March 31 | 06:00 - 16:00 |
| | | April 1 - October 31 | 04:00 - 20:00 |
| L. Monumental | March 1 – December 31 | April 1 - October 31 | 04:00 - 20:00 |
| Little Goose | March 1 – December 31 | April 1 - October 31 | 04:00 - 20:00 |
| Lower Granite | March 1 – December 31 | March 1 – March 31 | 06:00 - 16:00 |
| | | April 1 - June 14 | 04:00 - 20:00 |
| | | June 15 - August 31 | 24 hours |
| | | August 31 - October 31 | 04:00 - 20:00 |
| | | November 1 - December 15 | 06:00 - 16:00 |

## Environmental Conditions-Monitoring

### Monitor and Evaluate Migration Characteristics and River Condition

The Action Agencies will monitor and evaluate key biological and physical attributes of anadromous fish migrating through the FCRPS. These proposed actions include:

- *Monitor and estimate the abundance of smolts passing index dams.*
- *Monitor and describe the migration timing of smolts at index dams, identify potential problems, and evaluate implemented solutions.*
- *Monitor and document the condition (e.g., descaling, injury, GBT) of smolts at index dams, identify potential problems, and evaluate implemented solutions.*
- *Monitor and enumerate adult salmonids passing through fishways in the FCRPS, identify potential problems, and evaluate implemented solutions.*
- *Monitor and describe the migration timing of adults at dams in the FCRPS, identify potential problems, and evaluate implemented solutions.*
- *Monitor and evaluate the TDG, temperature, turbidity and flow at projects in the FCRPS relative to performance objectives.*

### *COE Program- TDG Standards & Monitoring (including associated parameters)*

The general policies of the Corps related to water quality are summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, dated February 1996 (Corps 1996). The Corps policy is to comply with water quality standards to the extent practicable regarding nationwide operation of water resources projects. "In past biological opinions, the NOAA water quality strategy was for the Corps to take the actions necessary to implement the spill program at the dams called for in the BiOp, including obtaining TDG variances from appropriate State water quality agencies. These variances would adjust the TDG criteria when “voluntary” spill is required to assist

juvenile salmonids transport past Corps projects. Since 1996, the states have provided waivers and rule modifications, and voluntary spill for fish passage has been managed as needed so that TDG levels in the tailraces of projects do not exceed 120%, and do not exceed 115% in the forebays of any Lower Snake River or Lower Columbia River dam or at the Camas/Washougal station, as measured by the 12 highest hourly measurements in any calendar day.

*Monitoring*- The total dissolved gas (TDG) monitoring program will consist of a range of activities designed to provide management information about dissolved gas and spill conditions. These activities will include time-series measurements, data analysis, synthesis and interpretation, and calibration of numerical models. Four broad categories of targets are involved:

1) Data acquisition, to provide decision-makers with synthesized and relevant information to control dissolved gas super-saturation on a real-time basis,
2) Real-time monitoring, to ascertain how project releases affect water quality relative to ESA Biological Opinion measures and existing state and tribal dissolved gas standards;
3) Trend monitoring, to identify long-term changes in basin wide dissolved gas saturation levels resulting from water management decisions; and
4) Model refinement, to enhance predictive capability of existing models used to evaluate management targets.

The Corps considers TDG monitoring a high priority activity with considerable potential for adversely affecting reservoir conditions and ongoing regional efforts to protect aquatic biota. It will make all reasonable efforts toward achieving at least a data quality and reliability level comparable to that provided in previous years.

Furthermore, the Corps believes it is important to maintain a two-way communication between those conducting the monitoring and the users of monitoring information. These interactions give decision-makers and managers an understanding of the limitations of monitoring and, at the same time, provide the technical staff with an understanding of what questions should be answered. Therefore, comments and recommendations received from users were, and continue to be, very useful in establishing monitoring program priorities and defining areas requiring special attention.

Actual data collection and transmission will begin in early March at the monitoring stations below Bonneville Dam in conjunction with the Spring Creek Hatchery release. Otherwise, the data collection and transmission will begin no later than 1 April for the entire monitoring network.. The exact starting date will be coordinated with the Corps' Reservoir Control Center (CENWD-PDW-R), project biologists and cooperating agencies, based on run-off, spill, and fish migration conditions.

The following data will be collected approximately every hour:

- Water Temperature ($^{o}$C)

- Barometric Pressure (mm of Hg)
- Total Dissolved Gas Pressure (mm of Hg)
- Gauge depth (feet)

Data will be collected at least hourly and transmitted at least every four hours. If feasible, the previous 12 hours of data will also be sent to improve the capability of retrieving any data that may have been lost during the preceding transmission. After decoding, all data will be stored in the CROHMS database. Data transmission at Libby and Albeni Falls (gauges operated by the Seattle District) will be done via radio to the NWS HEC-DSS database and the data sent via file transfer protocol (ftp) to the CROHMS database.

Given their direct relevance to fish mortality, the first three parameters (Temperature, Barometric Pressure, and TDG) will be collected on a first priority basis.

Daily reports summarizing TDG and related information will be posted on the Technical Management Team's (TMT) home page. Information provided on the homepage will include some or all of the following data:

- Station Identifier
- Date and Time of the Probe Readings
- Water Temperature, °C
- Barometric Pressure, mm of Hg
- TDG Pressure, mm of Hg
- Calculated TDG Saturation Percent (%)
- Project Hourly Spill, Kcfs (QS)
- Project Total Hourly Outflow (Total River Flow), Kcfs (QR)
- Probe depth, ft
- Calculated Compensation Depth, ft

The Reservoir Control Center staff will perform reconciliation of data received to CROHMS based on input from the field before the data are permanently stored in the Corps' Water Quality Data Base. Additional data posting in the TMT home page will continue.

Data will be collected at the locations detailed in the "Corps of Engineers Plan of Action for dissolved gas monitoring in 2007", an appendix to the Water Management Plan.

# Hydrosystem Action Effectiveness Evaluations

**Monitor and Evaluate the Effects of Configuration and Operation Actions**

The Action Agencies will monitor and evaluate the effects of the assorted operations and configurations implemented at projects in the FCRPS. These proposed actions include:

- *Monitor and evaluate the effects of existing spillways, modifications, and operations on smolt survival.*
- *Monitor and evaluate the effectiveness of traditional juvenile bypass systems and modifications to such, on smolt survival and condition.*
- *Monitor and evaluate the effectiveness of surface bypass structures and modifications on smolt survival and condition.*
- *Monitor and evaluate the effectiveness of turbine operations and modifications on smolt survival and condition.*
- *Monitor and evaluate overall dam passage with respect to modifications at projects.*
- *Monitor and evaluate the effectiveness of the juvenile fish transportation program and modifications to operations.*
- *Monitor and evaluate the effects of environmental conditions affecting juvenile fish survival.*
- *Monitor and evaluate the effectiveness of reducing predation towards improving juvenile fish survival.*
- *Investigate, evaluate and deploy alternative technologies and methodologies for fish passage and RM&E actions.*
- *Determine if actions directed at benefiting juveniles have an unintended effect on migrating adults (e.g., certain spill operations).*
- *Install and maintain adult PIT tag detectors in fish ladders at key dams in the FCRPS.*
- *Install and maintain PIT tag detectors for use in natal streams and tributaries as appropriate to support more comprehensive and integrated all-H monitoring designs and assessments of stray rates.*
- *Monitor and evaluate the effects of fish ladder operations and configurations on adult passage rates.*

The objective of Hydrosystem Action Effectiveness Evaluations is to assess the effects of hydrosystem actions on fish survival and fish condition in a quantitatively rigorous approach. This information will be critical for assessing the expected benefits of hydrosystem actions and their relative priority for implementation. This research requires well-designed experiments, typically with specified treatments, controls and adequate replication. Under the this strategy, the Action Agencies expect to implement the PA in coordination with other regional federal, state, and tribal agencies to achieve effectiveness research that quantifies the effect of hydrosystem fish passage improvement actions on the survival of juvenile and adult anadromous fish.

With respect to the biological sampling units, it is often difficult to separate out the effects of a hydro action on specific populations, particularly for studies staged at individual dams. Many of the research and monitoring efforts in the hydrosystem will focus on the ESU as often represented by the population-at-large a mix of hatchery and wild fish (e.g. action effectiveness, impact assessment, system survival). However, where possible AER studies will attempt to examine fish performance at the MPG scale (e.g. juvenile PIT detection, adult PIT detection, etc).

Both the USACE and BPA fund AER projects. All of these studies are designed and conducted under the auspices of the USACE Anadromous Fish Evaluation Program (AFEP). Details regarding each study can be found on the AFEP and NPCC web sites.

There are two general categories of AER projects, those that assess *biological effects* of configurations and operations and those that monitor changes in *physical or environmental conditions* associated with such actions.

## Juvenile Effects

The following action effectiveness projects are those that are associated with construction changes or changes that may be warranted within the period of the biological opinion towards improving juvenile survival through the hydropower system. These reflect actions and evaluations funded by the USACE primarily under the Anadromous Fish Evaluation Program. Biological parameters measured for these evaluations typically include passage survival, injury, delay in forebays and tailraces, spill passage efficiency, fish passage efficiency, migrational behavior, travel times, etc…

**Evaluate the effectiveness of existing spillways and improvements (AFEP)**

As a general rule, spillways at most Corps of Engineers operated projects provide the highest rates of survival for juvenile salmonids passing these dams. Where exceptions to this rule exist, modifications and evaluations are needed. Studies anticipated at Corps projects over the course of this BiOp include biological evaluations of existing and modified structures including flow deflectors, training walls, guidance devices, etc… and passage effects including survival and tailrace egress. Examples include:

***Bonneville Dam*** Estimate the direct and total effects of per bay discharge and flow deflector submergence on juvenile salmon and steelhead survival and injury.

***The Dalles Dam*** Estimate project and route specific survival rates, fish passage distribution, forebay behavior, tailrace egress, and the direct effects of spillway improvements including vortex suppression and stilling basin modifications.

***McNary Dam*** Evaluate the potential to improve the survival of juvenile fish

passing the spillway by optimizing egress.

***Ice Harbor Dam*** Evaluate the spillway for fish passage injuries and evaluate any warranted improvements.

***Lower Monumental*** Evaluate the potential to improve the survival of juvenile fish passing the spillway by identifying limiting factors and evaluate any warranted improvements.

***Lower Granite*** Evaluate the potential to improve the survival of juvenile fish passing the spillway by identifying limiting factors and evaluate any warranted improvements.

**Evaluate the effectiveness of traditional juvenile bypass systems and improvements (AFEP)**

Traditional juvenile bypass systems typically consist of turbine intake screens, bypass channels and conduits to transportation systems and/or back to the river. While these systems typically provide reasonably high survival around hydro projects, exceptions to this rule exist, and modifications and evaluations may be needed. Evaluations of bypass systems will likely include assessment of replacement of older facilities, improved bypass outfall locations, and improvements to existing screening systems. Specific examples include:

***McNary Dam*** Evaluate the potential to improve the survival of juvenile fish passing through the bypass system by optimizing tailrace egress and evaluate any warranted improvements.

***Ice Harbor Dam*** Evaluate any warranted modifications to turbine intake screens.

***Lower Monumental*** Evaluate an alternative outfall location towards improving juvenile survival.

***Little Goose Dam*** Evaluate an alternative outfall location towards improving juvenile survival.

***Lower Granite Dam*** Evaluate any improvements to, or rehabilitation of, the juvenile fish facility.

**Evaluate the effectiveness of surface bypass structures and improvements (AFEP)**

Surface bypass structures (sluiceways, RSWs, TSWs, etc…) provide juvenile fish with a means to pass around hydropower projects through what are believed to be safe and effective passage routes. Surface collection structures are meant to take advantage of

juvenile salmonids surface orientation (top 10-20 feet of water) on their downstream migration as opposed to traditional bypass systems and spillways (which typically provide a passage route 50 feet or more from the water's surface). Project evaluations will estimate project and route specific survival rates, fish passage distribution (e.g. FPE and SPE), forebay behavior, and tailrace egress for juvenile fish. Specific examples of action effectiveness research on surface bypass routes include:

| | |
|---|---|
| ***Bonneville Dam*** | Evaluate prototype and post-construction performance of Powerhouse 1 sluiceway improvements by estimating fish passage efficiency, sluiceway passage efficiency, and sluiceway passage survival.<br>Estimate fish passage and sluiceway passage efficiency at Powerhouse 2 with and without a guidance device (i.e. a trash shear boom) in the forebay. |
| ***The Dalles Dam*** | Evaluate the effectiveness of sluiceway entrance improvements on juvenile salmonid passage efficiency. |
| ***John Day Dam*** | In support of prototype and post construction evaluations of surface flow bypass and tailrace egress improvements. |
| ***McNary Dam*** | Evaluate surface passage alternatives as a means to improve the passage survival of juvenile fish. |
| ***Ice Harbor Dam*** | Evaluate the RSW for fish passage behavior and injuries and evaluate any warranted improvements.<br>As warranted, evaluate any follow on actions in the surface bypass plan for juvenile passage improvements. |
| ***Lower Monumental*** | Evaluate an RSW for fish passage behavior and injuries and evaluate any warranted improvements, (2008 and 2009).<br>As warranted, evaluate any follow on actions in the surface bypass plan for juvenile passage improvements. |
| ***Little Goose Dam*** | Evaluate an RSW for fish passage behavior and injuries and evaluate any warranted improvements (through 2010).<br>As warranted, evaluate any follow on actions in the surface bypass plan for juvenile passage improvements. |
| ***Lower Granite Dam*** | As warranted, evaluate any follow on actions in the surface bypass plan for juvenile passage improvements. |

**Evaluate the effectiveness of turbine operations and improvements (AFEP)**

Overall, the survival of fish passing through FCRPS turbines appears to be relatively low.

However, while the survival of fish through some turbines has been estimated as low as 72%, other turbine survival has been estimated as high as 96%. The higher observed survival rates demonstrate a potential to significantly improve the survival of fish passing through other similar type turbines. By developing and implementing operational and design improvements, it is not unreasonable to expect that survival rates for fish passing through FCRPS turbines could greatly improve. Furthermore, juvenile salmonids continue to pass through turbines despite considerable efforts to prevent or reduce it. Continuing evaluations towards understanding and improving turbine survival include:

| | |
|---|---|
| ***Systemwide*** | Continue to investigate the effects of turbine pressure cycling on juvenile salmonid survival, and implement improvements if warranted.<br>Conduct biological index testing at FCRPS powerhouses as warranted as a means of improving turbine operations for fish passage, egress and ultimately, dam passage survival. |
| ***Bonneville Dam*** | Estimate fish survival at Powerhouse 1 following minimum gap runner replacement work. |
| ***McNary Dam*** | When the prototype new turbine is installed (2009) estimate survival, injury, and FGE. |
| ***Ice Harbor Dam*** | Conduct studies to support replacement of existing turbines. |

**Evaluate the effectiveness of the juvenile fish transportation program and improvements to operations (AFEP)**

During the interim, the Action Agencies will continue the current fish barging program for improved survival of Snake and Columbia River salmon and steelhead with some modifications. The barging strategy will be adjusted as needed, based on new scientific information. Evaluations of transportation typically include ratios of smolt to adult returns of transported and inriver migrants, estimates of differential delayed mortality of transported fish, etc…

**<u>Spring Migrants</u>**

An evaluation of weekly smolt to adult return rates will be conducted to evaluate and refine the appropriate operation for transportation during the spring season. More precise transportation data in the April time frame for wild yearling Chinook salmon and steelhead is expected to provide clarity regarding the effects of transportation to the portion of the run where data is typically less certain. More precise data in the May time frame should allow for correlation of physical and environmental factors to guide the AAs as to the appropriate

triggers of how to operate for transportation on an annual basis towards maximizing adult returns.

Upon complete installation of surface bypass collectors and modified bypass outfalls on the Snake River dams, the Action Agencies propose to conduct an intensive transportation study to evaluate seasonal SARs of bypass and transported wild steelhead and yearling Chinook salmon. The information gained from this research is expected to inform the AAs as to whether constructional and operational changes in the hydrosystem allow for alternative operations for maximizing adult returns.

The AAs propose to perform a bypass and transportation evaluation at Lower Monumental Dam to determine if wild Chinook and steelhead return at higher rates depending on management strategy. This research is expected to inform the AAs on whether transportation or bypass is the preferred management strategy for collected fish at Lower Monumental Dam.

The AAs will continue to fund data collection and reporting for the transportation evaluation at McNary Dam. This research is expected to inform the AAs on whether inriver migration, transportation or bypass is the preferred management strategy for upper Columbia Chinook and Steelhead. Other information gathered could yield a better understanding of whether seasonal or species specific transportation is a reasonable management strategy.

The AAs will continue data collection and reporting for the transportation evaluations for Lower Snake River ESUs. This research is expected to inform the AAs on whether inriver migration or transportation is the preferred management strategy for Snake River Sp/Su Chinook and steelhead. Other information gathered could yield a better understanding of whether seasonal or species specific transportation provides greater adult returns.

The AAs propose to investigate the feasibility of conducting a sockeye transportation study and implement a study if warranted.

The AAs propose to monitor for and identify the potential mechanisms for differential delayed mortality of transported Chinook and steelhead. If any mechanisms are identified, evaluations of operational or constructional alternatives to reduced delayed mortality would be conducted.

The AAs propose to examine the transportation operation to determine if adult returns can be increased by releasing fish from barges at an alternative release site. Releasing fish closer to the estuary under the appropriate environmental conditions may have the potential to reduce predation on smolts, thereby increasing adult returns.

The AAs propose to monitor the homing of adult fish that were transported as juveniles using PIT-tagged fish and adult pit tag detectors.

**Summer Migrants**

The AAs propose to conduct a long term operations evaluation towards determining the appropriate management strategy towards maximizing adult returns for Snake River fall Chinook. These intensive RME efforts for subyearling Chinook would occur at least through 2008 and will require specific operations during the study. Major components of this analysis are expected to include evaluating early life history and migration behavior, the performance of hatchery fish as surrogates for wild fish, and investigating the benefits of late season transportation. This may also include tagging production fish as comparisons when both the wild and surrogate groups are tagged. Continuation of RME regarding the life history of Fall Chinook will be important to this effort.

A comprehensive study plan (transportation/inriver migration) for Snake River Fall Chinook will be developed that addresses the relevant issues associated with the study design, such as the source and numbers of fish to be marked, the analytical methods to be used, the operations to be implemented, and the plan for independent scientific review. This study plan will be developed by 2007, reflective of the comments received to date in the collaborative process.

**Evaluate environmental conditions towards improving juvenile fish survival (AFEP)**

Environmental conditions associated with fish passage operations can cause unintended consequences to rearing and migrating fish. Efforts towards reducing mortality or harm due to these include:

***Bonneville Dam*** Investigate the effects of gas super-saturation on emergent chum fry downstream from Bonneville Dam as warranted. (Continuing evaluations TDG monitoring of chum redds in 2007)

***McNary Dam*** Evaluate alternatives for limiting water temperature extremes in the juvenile bypass system.

***Lower Monumental*** Determine if mortality or residualization of fall Chinook is related to reservoir conditions or operations during summer months

**Evaluate the effectiveness of reducing predation towards improving juvenile fish survival (AFEP & BPA).**

Predation is an important factor that could be limiting recovery of Columbia Basin salmonids. To improve conditions for listed stocks, the action agencies are proposing to:

***Lower Monumental*** Evaluate methodologies to reduce predation on juvenile fish in the forebay and tailrace towards improving juvenile survival.

***Ice Harbor*** Evaluate methodologies to reduce predation on juvenile fish in the forebay and tailrace towards improving juvenile survival.

***McNary*** Evaluate methodologies to reduce predation on juvenile fish in the forebay and tailrace towards improving juvenile survival.

***Avian Predation*** Determine the effectiveness of Caspian tern management measures implemented to reduce the level of avian predation on salmonid stocks in the Columbia River estuary. Also assess the impact that Caspian terns are having on similar juvenile salmonid populations at alternative locations and determine if the impact is of sufficient concern to consider modification of the FEIS proposal to redistribute Caspian terns to those locations. Monitor inland Caspian tern colonies and evaluate the impact of system operations and other factors on avian predation on the juvenile salmon outmigration. Provide information to support a comprehensive management plan for inland avian predation. .

Determine the population level of double-crested cormorants and other avian predators in the lower Snake and Columbia Rivers, and estuary and the level of their predation on salmonid stocks in the Columbia River. Assess the methods available to manage predator habitat and/or population levels to reduce their level of predation on salmonid stocks. Establish the baseline information required prior to develop an EIS concerning management of this species.

***Fish Predation*** The Pikeminnow management program is implemented to reduce the level of fish predation on salmonid stocks in the Columbia River System. It also provides for monitoring harvest rates and effects on the pikeminnow population.

See the separate section of the PA on Predation RM&E for additional information.

**Investigate, evaluate and deploy alternative technologies for fish passage and RM&E actions**

To improve the evaluation process and designs of future fish passage facilities, a level of baseline research is often required. The Action Agencies propose to:

- Evaluate the effects of different entrance designs on the behavior of juvenile fish (e.g., The Dalles sluiceway, Bonneville corner collector, Ice Harbor RSW, Lower Granite RSW) towards designing consistent and effective surface bypass alternatives.
- Continue to develop the capability to estimate system (Lower Granite Dam to the Columbia River mouth) survival for juvenile salmon and steelhead.
- Continue to develop technologies that will enable life cycle survival estimates that can be related back to FCRPS migration histories.
- Continue developing potential improvements to juvenile PIT tag detection systems and alternative technologies associated with high discharge fish passageways (e.g., Bonneville corner collector, spillways and turbines) and tributaries.

## Adult Passage Effects

While adult survival through the hydrosystem is consistently high, some areas exist for improving delay.

***Bonneville Dam***

- Document the spatial and temporal distribution of sea lion predation attempts, estimate predation rates, and estimate overall seal lion abundance in order to assess the effects of a combination of deterrent actions (exclusion gates, acoustics, harassment) and their timing of application on spring runs of anadromous fish passing Bonneville Dam (AFEP).
- Evaluate effectiveness of running B2CC for steelhead kelt downstream passage during winter months, first by investigating fallback records through the JBS and if warranted by evaluations with B2CC operating in March (AFEP).

***The Dalles Dam***

- Evaluate use of sluiceway as a fallback route by adult steelhead in November and December (AFEP).

***John Day Dam***

- Where warranted, assess the effects of juvenile fish passage improvements on adult salmon and steelhead passage times and fallback rates (AFEP).
- Evaluate the effects of adult ladder improvements on adult fish passage times and ladder use (AFEP).
- Where warranted, assess the effects of juvenile fish passage improvements on adult salmon and steelhead passage times and fallback rates (AFEP).

***System***

- Further develop the adult PIT tag system to interrogate adult passage in natal streams and tributaries. This will allow for further enumeration of pre-spawning mortality, straying rates, and reduced spawning success of adult upstream migrating fish, which may be due to or exacerbated by passage through the FCRPS hydro projects. If measures are identified which will reduce the pre-spawning mortality rate or straying, the Action Agencies will implement these measures, as warranted (AFEP/BPA).
- Evaluate the effects of changes in fish ladder temperatures if modifications are made to decrease temperature differences within the fishway (AFEP).
- Install Adult PIT detection at The Dalles (BPA)
- Adult PIT at JDD (BPA)
- Report on water temperature effects on adult salmonids between McNary Dam and the confluence of the Clearwater River (AFEP).
- Adult telemetry evaluation to help identify factors that contribute to successful spawning or unaccounted loss continued in 2004. Data analysis is scheduled through 2005 and the final report will be available in 2006. PIT tag evaluations are planned for future years. Spawning success evaluations are planned into 2008.

**Post Construction evaluation (Flow deflectors, e.g.)**

- If modifications to flow deflectors are warranted, i.e. raising or lowering them to improve fish survival, evaluating the effects of these modifications on the resultant TDG would be required (AFEP).

# Critical Uncertainty Research

**Investigate Critical Uncertainties:**

The Action Agencies will fund research directed at resolving critical uncertainties that are pivotal in life cycle model analyses. These proposed actions include:

- *Investigate and quantify delayed differential effects (D) associated with the transportation of smolts in the FCRPS as needed.*
- *Investigate the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville.*

- *Conduct a workshop every other year with members of the Independent Scientific Advisory Board to review current research and monitoring approaches on post Bonneville mortality for transported and non-transported fish.*
- *Investigate, describe and quantify key characteristics of the early life history of Snake River Fall Chinook in the mainstem Snake, Columbia and Clearwater rivers.*
- *Investigate effects of adult passage experience in the FCRPS on pre-spawning mortality.*

The Action Agencies, NOAA, and state and tribal Fishery agencies have identified several topics of critical uncertainty that are deemed to require resolution through targeted research. Many of these are reflected in the management questions appearing near the beginning of this plan. These are broad issues that span the system and are not locally focused like the AER actions. There are four topic categories of critical uncertainty research, as the bullets indicate. These categories are considered to be critical because either passage model or life cycle model analyses are very sensitive to these parameters, or our ability to accurately quantify these parameters is deficient. Thus, there is a critical need for targeted research on these topics.

- **Delayed Differential Effects Associated With Transportation (D)-**What is the magnitude of delayed effects associated with transporting smolts? Can inriver passage provide greater adult return rates than transporting smolts, and under what passage conditions? Determine if Snake River subyearling fall Chinook benefit from being transported when spill is provided. Determine mechanisms of differential delayed mortality of transported fish (D). This may include evaluations of ocean entry timing, physiological assessments, and transportation of stocks separately, et cetera. This action is being considered in the critical uncertainties section because of the implications of the varied life history of Snake River Fall Chinook.
- **Post-Bonneville Survival Effects Associated With Passage Through The FCRPS (L)-** Do smolts migrating through the FCRPS incur effects that are manifested as mortality later in the life cycle, and what is the magnitude of such effects? What are the causes of such effects, and to what extent can they be rectified by altering operations? Projects that attempt to estimate post-Bonneville survival of smolts having migrated through the FCRPS may contribute to resolving this issue.
- **Early Life History of Snake River Fall Chinook-** The complex life history patterns exhibited by this ESU have thwarted attempts to estimate system survival and hydrosystem impacts in general. An ongoing research effort by USFWS continues to reveal new information that will clarify important processes affecting this ESU.
- **Effects of Passage on Pre-spawning Mortality-** Some agencies have raised concerns that adults migrating through the FCRPS may be encountering conditions that exacerbate pre-spawning mortality, which would be expressed in the tributaries. Thus far limited radio telemetry investigations have been conducted.

**Delayed effects associated with transport (D) and inriver passage (L)**

These two research topics address issues regarding the existence, magnitude and mechanisms affecting delayed effects associated with smolt passage through or around the FCRPS. Uncertainty regarding the existence and magnitude of delayed or latent mortality has been a critical uncertainty in past FCRPS BiOps and was a significant topic of discussion within the BiOp Remand Collaboration Process. The uncertainty associated with these issues is so acute that no less than eight regional hypotheses now characterize our interpretation of limited and confounding information on these matters. These hypotheses were posed through Collaboration Process Workgroups and were submitted by the Policy Working Group to the ISAB for review. Briefly, the hypotheses are:

1. Latent mortality associated with inriver migration is a function of water travel time (surrogate for migration speed) for wild Snake River yearling Chinook.
2. Latent mortality associated with inriver migration is a function of arrival timing at Bonneville Dam for wild Snake River yearling Chinook.
3. The four Snake River dams cause latent mortality in inriver migrants averaging 59-64% for wild Snake River yearling Chinook.
4. Latent mortality of inriver migrants is low, confounded and unquantifiable for wild Snake River yearling Chinook.
5. Delayed effects associated with transporting smolts as reflected in historical estimates is driven by climate processes largely manifested in the marine environment.
6. Delayed effects associated with transporting smolts can be estimated from existing data by accounting for sampling error, for wild Snake River yearling Chinook and steelhead.
7. Delayed effects associated with transporting smolts are a function of arrival date in the estuary.
8. Delayed effects associated with transporting smolts vary throughout the season for wild Snake River yearling Chinook.

The ISAB Latent Mortality Report (April 6, 2007) review of these hypotheses concluded that:

- The hydrosystem causes some fish to experience latent mortality, but strongly advises against continuing to try to measure absolute latent mortality. Latent mortality relative to a damless reference (e.g., hypothesis 3, upstream versus downstream population comparisons) is not measurable due to numerous confounding factors.
- Research should focus on estimating total post-Bonneville mortality for in-river migrants and transported fish, which is the critical management issue for recovery of listed salmonids. Efforts would be better expended on quantifying these total effects, which can be measured directly.
- More effort should be put into monitoring and estimation of processes that can be measured directly and used to inform modeling estimates and relationships for post-Bonneville mortality.

Several research projects currently attempt to resolve the strengths and weaknesses of these hypotheses. Research projects (13) that either are providing, or will provide, data and analyses to address these delayed mortality hypotheses are identified in Table 1 of Appendix 1. Some of these projects have been in place for several years, and the studies address a broad range of issues. However, the collective information obtained to date has not yet been synthesized.

The Action Agencies propose that a workshop be held within twelve months of BiOp completion (and every other year thereafter) to collate and synthesize the new information and review the need and direction of current research in light of the ISAB review. The purpose will be to determine if the collective research can resolve the hypotheses posed above, what modifications to the research may be warranted, and what additional research may be needed. This can help inform decisions regarding the fate of existing studies, and/or the need for new refocused research efforts. The workshop should include not only results from the research projects listed here, but relevant analyses from other investigators, e.g., the NOAA analyses depicting the linkage between latent mortality and the timing of smolt arrival in the estuary.

We expect that results from the workshop will also assist in more clearly identifying PIT tagging and hydro acoustic needs for wild and hatchery stocks that could be used in future latent mortality and transport evaluations. Of keen interest are; population (MPG) coverage, sample size requirements and supporting rationale based on a sound analytical framework.

**Snake River Fall Chinook Investigations**

At least two studies focus directly on early life history and transport effects on Snake River fall Chinook. These studies are critical for formulating effective management strategies for this ESU. Unfortunately the transport evaluation has been postponed for 2007, and will be implemented in 2008. Without this information it will be impossible to determine whether transport or inriver passage with spill, or some combination will maximize survival. No model analyses can resolve this matter with existing data. This gap must be filled posthaste in the collaboration process.

**Pre-spawning Mortality**

Currently there are no research projects or proposals occurring to directly address the effects of migration experience of adults on their mortality rates prior to spawning. However, such a research effort was recently concluded and results are forthcoming. That project was a radio telemetry study using known source Snake River spring/summer Chinook and was funded by the Corps.

# Implementation and Compliance Monitoring

The Action Agencies will prepare ***implementation plans*** to document our specific strategies, priorities, actions, measurable targets, and timetables. In these plans, the Action Agencies will identify ESU-specific targets and actions. We will address both the actions that are essential under this PA and the conservation actions and measures that are not a requirement for the avoidance of jeopardy but which aid in the recovery of listed species. The Action Agencies will maintain a ***BiOp database*** to provide project and action level detail for planning and reporting purposes. This approach will be efficient and provide the most up-to-date information about the status of actions and projects being implemented.

Implementation plans will identify responsibilities specific to the Action Agencies and will serve to coordinate agency efforts with other appropriate regional processes. Those efforts would typically include coordination due to a statutory obligation for the Federal government (BPA/Council), voluntary coordination among Federal agencies (Federal Caucus), and coordination committed to under this FCRPS BA and subsequent BiOp. Some of the Federal/non-Federal agencies and forums included in coordination activities include; TMT, SCT, Northwest Environmental Data-Network and Pacific Northwest Aquatic Monitoring Program (PNAMP).

## Progress Reporting

We will use the project level detail contained in the Action Agencies' BiOp database to track results and assess our progress in meeting programmatic level performance standards. We will track overall population performance through annual reports of adult abundance and trends in adult abundance for listed ESUs. The results of the progress reports will inform adjustments in future year plans through adaptive management.

The Action Agencies will prepare ***annual progress reports*** based on our implementation plans. The progress reports will document our ability to achieve ESU-specific performance targets established in this PA and updated through our implementation plans. In several instances the PA specifies anticipated dates for implementation of certain actions that are important steps toward achieving performance standards. The Action Agencies consider those dates to be benchmarks for implementation and will report on the status of achievement of these benchmarks in the annual progress report

The Action Agencies will prepare a ***comprehensive programmatic evaluation*** of progress after 2012 and 2015. These check-in reports will also serve as the annual progress report for the year in which they are presented. Comprehensive evaluation reports will summarize cumulative accomplishments over the relevant time period, review survival and fish return status, propose corrective actions where we are off track, and address key variables, new research, and monitoring and evaluation results.

# Coordination

The USACE RM&E activities are coordinated in the following manner with the agencies indicated.

## Anadromous Fish Evaluation Program Coordination

Coordination with regional fish agencies and tribes has always been a key component of the Corps' fish passage program, including the AFEP. The Corps conducts technical coordination through three interagency work groups including the Fish Facility Design Review Workgroup (FFDRWG), Studies Review Workgroup (SRWG), and the Fish Passage Operations and Maintenance workgroup.. Primary work group participants include fish passage specialists with the Idaho, Oregon, and Washington fish and wildlife/game departments, the Columbia River Inter-Tribal Fish Commission, NMFS, USFWS, Northwest Power Planning Council, and Bonneville Power Administration. Meetings are open to any interested participants and the work group mailing lists include a wide array of entities and persons interested in Columbia basin fish restoration.

***Studies Review Work Group***

Research, monitoring, and evaluation studies are developed and reviewed by the Studies Review Work Group (SRWG). The Corps works with SRWG participants to develop study targets. The group then reviews draft proposals and reports within the 6 areas of the AFEP. These include: surface bypass, transportation, conventional bypass systems, in-river passage (spill, gas, and reach survival), adult fish migration, and turbine passage. The coordination schedule for Fiscal Year 2007 AFEP studies features SRWG meetings and review between February 2006 and January 2007 to accomplish study development tasks (Table 2 ).

**Table 2 . Typical Annual SRWG Program Schedule:**

| | |
|---|---|
| SRWG Sub-group meetings | February-April |
| Send out research summaries to SRWG | May |
| Research Summary Review meeting | Early June |
| Final Comments research summaries | Late June |
| Requests for Pre-Proposals | Late June |
| Preliminary Proposals Due | July |
| Distribute Pre-proposals to region | August |
| SRWG Preliminary Proposal Review | Late August |
| Final Comments Due | September |
| Revise Proposals | October |
| Final Proposals out for review | October |
| Annual Research Review | November |
| Final Proposal Review | Late November |
| Briefing on Funded Proposals | January |

***Fish Facility Design Review Work Group***

The Fish Facilities Design Review Work Group (FFDRWG) provides input to engineering and design of fish facility modifications and new passage technologies. Participants review new or modified facilities from concept through engineering, design, and construction phases. Review emphasis is on application of biological criteria and impacts of structures and their operation on fish behavior, condition, and survival.

***Fish Passage Operations and Maintenance Work Group***

The Fish Passage Operations and Maintenance Work Group (FPOM) provides input on ongoing project operations issues. This includes any fish passage problems that may arise at the projects during the passage season. The group comments on the adult fish counting program, outage schedules for turbines and fishways, and special operations required to conduct AFEP studies or other needs. The FPOM also reviews the Corps' annual Fish Passage Plan. This document describes fish facility and project operating criteria that will be in effect in a particular year to provide acceptable passage conditions.

The SRWG and FPOM meetings are chaired jointly by the Portland and Walla Walla Districts. FFDRWG meetings are hosted separately by the two districts due to the group's workload. Recommendations and decisions are documented in meeting minutes. Action items are implemented by District staffs or by other participants as appropriate.

***Relation to Regional Forum Groups***

The Regional Forum process has been developed since 1995 by NMFS and other regional entities to implement ESA provisions for protection and recovery of listed salmon species. One of these groups, the System Configuration Team (SCT), prioritizes and recommends to the Corps elements of the CRFM for implementation. Those CRFM items that require biological studies become priority areas of investigation for AFEP. These priorities are used by the technical coordination groups to recommend AFEP study objectives. Most disagreements or issues concerning varying points of view and interpretations of technical information are resolved in the work groups. Any unresolved issues are brought to Regional Forum groups for further discussion and resolution. Updates of SRWG and FFDRWG activities are provided to SCT. SCT addresses issues that are not resolved in the technical coordination groups. Issues or disputes not resolved by SCT are forwarded to the Implementation Team (IT) for resolution. If the IT is unable to agree on a course of action, the matter may be referred to the Executive Committee (EC) for a recommendation. Regardless of how far the disputes are elevated, the Corps' Northwestern Division Commander is responsible to make the final decision based on recommendations that emerge from the Regional Forum process.

## NPCC-BPA Fish and Wildlife Program

BPA funded RM&E activities are coordinated under the auspices of the NPCC Fish and Wildlife Program.

## Coordinating FCRPS RM&E through the Collaboration Process

Analytical methods and experimental deigns called for under this AA RME plan will continue to be developed in collaboration with the fishery agencies and tribes. The Action Plan for status monitoring will be developed in ongoing collaboration with the state and federal fishery agencies and tribes in coordination with status monitoring needs for estuary/ocean, habitat, hatcheries, and harvest.

# Data Management

Data sets that are required to execute the monitoring program called for in this plan are housed in database systems at several agencies. Source sites are listed here:

**Adult Passage**

- Adult counts at dams by species *(COE, NWD)*
- PIT Tagged fish detected at dams *(PSMFC)*

**Juvenile Passage**

- PIT Tag release & detection data *(PSMFC)*
- Smolt counts and Indices: dams, transported etc. *(COE, FPC)*

**Environmental Data and River Conditions**

- River Environment: flow, spill, etc. *(COE, NWD)*
- Water Quality: temperature, TDG, turbidity, etc. *(COE, NWD)*

In addition to these source sites, there are other data management sites that compile and synthesize the source information and calculate a variety of passage estimates that characterize fish passage performance, e.g. , adult conversion rates, smolt travel time, transport percentages, etc. Those sites include database systems at the Fish Passage Center, Battelle Pacific Northwest Laboratories, Streamnet, and the University of Washington.

Most estimates calculated as part of status monitoring are archived in one or more of these locations. However, some critical data sets are currently held officially by NOAA Fisheries. These include historical estimates of smolt system survival (inriver and combined with transport), and the latest dam configuration passage and survival estimates. Both are pivotal, since they are fundamental components for calibrating and configuring passage models used by the region. We propose that these estimates be archived on one or more of the regional database systems, to permit easy examination of that information.

*This is not a final federal agency product. Rather, it is a pre-decisional document prepared by the Action Agencies that reflects present understandings of currently available information and analyses, and of the progression of discussions with the sovereigns in the collaborative process. Revisions and refinements are to be expected based on further discussions with the sovereigns over new and modified proposed federal actions upon which the action agencies will ultimately consult. Finally, the information in this product does not constitute an analysis of whether the identified measures would or would not jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Furthermore, this document does not in any way interpret or apply the regulatory definitions of the statutory phrases "jeopardize the continued existence of" and "destruction or adverse modification."*

# Tributary Habitat Research, Monitoring and Evaluation Proposed Action

**Table of Contents**



## Introduction

This appendix to the RM&E Proposed Action (PA) provides additional details regarding monitoring and evaluation that will be implemented to answer key management questions regarding the achievement of tributary habitat performance standards/targets, identification and understanding of habitat related limiting factors, and the effectiveness of habitat actions. Performance metrics, monitoring approaches, and proposed actions needed to answer these management questions are identified, along with the associated proposed actions needed for tracking implementation of tributary habitat projects, coordination of these research and monitoring actions with regional agencies, and management of tributary habitat data.

## Management Questions

The following are the primary management questions with respect to tributary habitat actions. The RM&E actions described in this section are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions relative to the FCRPS PA.

(1) Are tributary habitat actions achieving the expected performance standards and targets?
(2) What are the relationships between tributary habitat actions and fish survival or productivity increases? What actions are most effective?
(3) What are the limiting factors or threats preventing the achievement of desired habitat or fish performance objectives?

Answers to these questions will require a combination of status monitoring, action effectiveness research, critical uncertainty research, and project implementation and compliance monitoring. Information from monitoring and research will inform assessments of fish performance relative to annual performance standards and longer term targets and guide adaptive management decisions.

## Performance Measures

The Action Agencies have identified performance measures that will be monitored and evaluated relative to performance *standards* (benchmarks) and performance *targets* (longer term goals) to assess progress and inform adaptive management actions. There are two general categories of performance measures with associated monitoring requirements: 1) Programmatic (i.e. project tracking); and 2) Biological and Environmental (i.e. survival, habitat conditions). The programmatic performance measures are tracked through project implementation and compliance monitoring. The Biological and Environmental performance measures are tracked and evaluated through status monitoring, action effectiveness research and critical uncertainty research in combination with existing and developing quantitative models. Performance *standards* are monitored frequently to insure accountability and adherence to proposed actions. They have potential contingencies or other time critical corrective actions that may be associated with them. Performance *targets* are evaluated over longer time periods as new information and learning is applied through analytical models to check for progress toward expected life stage survival improvements and trends in population performance. Performance targets inform longer term adaptive management decisions and prioritization of options across populations with different relative needs.

Survival and productivity benefits for tributary habitat actions that are expected to be implemented in the periods FY07-09 and for FY10-17 have been estimated for individual populations and used within the Biological Assessment. These estimated benefits provide the long term performance targets for individual populations and their habitats. In addition, potential changes in limiting factors and overall habitat condition resulting from habitat actions implemented within the two time periods have been estimated based on local biologist input (See Attachment 1 for more information on the method of estimating benefits of habitat actions). Performance standards have been set for annual tracking of project implementation (linked to

expected changes in limiting factors and their habitat) projected for the periods FY07-09 and for FY10-17, which were used to estimate the long term survival benefits. RM&E will be used to confirm and improve our understanding of the relationships between different habitat actions, the environment and the survival and productivity performance measures. As this information is developed and relationships and models are updated, the AA will re-confirm the modeling estimates of expected survival improvements associated with actions. Specific tributary habitat performance standards, contingencies, and performance targets, and their relation to the broader PA are identified in more detail in the Accountability for Results and Risk Section of the PA.

The AA are using a modeling approach to estimate the benefits of actions at both individual projects and collective project levels. The models are based on the relationships between habitat and the fish performance measures. Attachment 1 to this appendix provides information on models and analytical tools that were used to estimate benefits and performance measures for the Biological Assessment and PA. As we collect new information about the effects of our actions, we will use the monitoring data to improve our models of the habitat and fish relationships and improve the model performance, both in our ability to predict at multiple scales and with higher certainty. Thus the monitoring and modeling strategy will adaptive as new information is obtained.

## Monitoring Precepts

Past monitoring activities have taught us much about monitoring tributary habitat actions. Some of the most important lessons learned include:

(1) Research and monitoring should support a decision framework (evaluation) that is adaptive. The adaptive management strategy should start with a set of management questions and performance measures.

(2) Since all tributary habitat projects can not be monitored due to time and cost constraints, an analytical process is needed to support the decision framework. Models will be required to predict the effects of actions on fish populations over broad temporal and spatial scales. Models should be chosen that provide the most accurate predictions and that are most transparent to the users and decision makers. The model outputs are the data metrics associated with the performance measures. The data inputs to the models then help define the field data collection.

(3) Status and trend monitoring of fish populations (juvenile and adult) and habitat conditions is needed to establish baseline conditions and to develop a reference for large-scale, long-term patterns that may confound population-scale analyses of habitat restoration effects.

(4) Population-level responses to tributary habitat actions can only be detected at the appropriate spatial and temporal scales. Measurements of the effects of restoration actions may occur at multiple spatial and temporal scales, but the monitoring program must be designed ultimately to evaluate responses at the population scale, or at least the scale of major life-history components, and over multiple years or generations.

(5) Individual habitat actions generally do not directly impact population processes. Their direct effects are to modify physical or biological habitat condition. Therefore, responses of

individual habitat actions are most easily detected at the scale of the action (i.e., reach or habitat unit scale).

(6) For populations that may be effected by hatchery programs or modifications to those programs, the evaluation and monitoring approach must take these effects into account and appropriately integrate them into the study design.

Given these precepts, one should be able to develop valid approaches to monitoring the effects of tributary habitat actions.

## Problems with Ideal Monitoring Approaches

In general, the basic before-after, control-impact (BACI) design provides a foundation for monitoring the effects of tributary habitat actions on population productivity and distribution. The validity of the basic BACI design can be extended by including sampling at multiple Control and Impact locations on multiple occasions during the Before and After period (MBACI). Better yet, the certainty of inferences may be further improved by establishing several pairs of Control and Impact locations that are sampled on multiple occasions during the Before and After period (MBACI(P)). The intent of these designs is to reduce the likelihood of alternative explanations for differences seen in treatment and control locations. These designs, if implemented correctly, include the four essential ingredients of an ideal design: randomization, replication, controls, and independence.

The "ideal" design is rarely, if ever, feasible at the population scale because of losses of control and/or treatment areas, spatial arrangements of populations, lack of randomization, lack of independence, the nature of variables measured, and institutional and economic arrangements. BACI-type designs require institutional control over the time and place of implementation of treatments and the selection and preservation of control areas. This is rarely feasible at the scale of populations. In reality, controlling social, economic, and political arrangements at the scale of populations is very difficult and the lack of experimental control often results in treatments being implemented at different times and intensities, and control areas being treated (loss of independence). Maintaining control populations for comparison with treated populations for long periods of time is very difficult institutionally.

In addition, some performance measures, such as fish abundance, biomass, and productivity are quite variable in space and time. Variability in fish metrics may result from different seeding levels (recruitment) and density-dependent factors that can be independent of habitat conditions. Large variability in fish metrics makes it difficult to assess effects of tributary habitat actions on population productivity.

Given the problems associated with implementing BACI-type designs at the scale of populations, alternative approaches are needed. Although these alternatives do not provide the level of certainty of inference that attends MBACI or MBACI(P) designs, the alternatives may demonstrate causation at the population scale if implemented correctly.

## Monitoring Approach

The AA plan to undertake the following 4 primary approaches to assess habitat treatment effects on population productivity and distribution:

(1) ***Intensively Monitored Watershed (Single Habitat Type)***—This IMW involves the implementation of a single habitat action type in a population-scale area. The treated area is matched with a control population-scale area. Effects of a specific action type are assessed through monitoring population productivity in a treatment-control or intervention-analysis context.

(2) ***Intensively Monitored Watersheds (Multiple Habitat Types)***—This IMW involves the implementation of multiple habitat action types in a population-scale area. The treated area is matched with a control population-scale area. Cumulative effects of the actions are assessed through monitoring population productivity in a treatment-control or intervention-analysis context. This approach cannot by itself separate the effects of individual habitat action types on population productivity.

Both IMW approaches provide inferences at the population scale; however, only the IMW (single habitat type) can assess the effects of specific habitat types on population productivity. The lack of spatial replication and randomization limits the certainty of inferences of IMWs. In addition, they require long-term institutional control, which means that relatively few of these can be implemented successfully.

(3) ***Status/Trend Monitoring***—Status/trend monitoring of population productivity and habitat condition is a long-term effort (decades) that assesses effects of habitat actions through correlation of productivity change to habitat condition and action reporting. Status/trend monitoring provides higher certainty of inference if before-after data are collected at the population scale and physical and biological effects are measured at the reach or habitat scale.

(4) ***Project-based Monitoring***—Project-based monitoring includes measuring physical and biological effects of individual habitat actions at a reach or habitat scale. Because this type of monitoring does not directly measure the effects of habitat actions on the population, status/trend monitoring should be used to assess possible changes at the scale of the population. Effects of individual actions are assessed through extrapolation of action influence and modeled connection of habitat condition to population processes.

(5) ***Watershed-scale Monitoring***—This approach is similar to IMWs, but is implemented at a sub-population scale (a watershed scale smaller than the geographic area of the population). As with IMWs, this approach may include multiple habitat action types or single action types. Because watershed-scale monitoring does not directly measure the effects of habitat actions on the population, status/trend monitoring should be used to assess possible changes at the scale of the population.

These monitoring approaches lie along a gradient of inferential certainty from relatively weak to relatively strong (Table 1). IMWs provide more inferential certainty than do the other approaches, because IMWs are design-based at the population scale. That is, inferences from

IMWs are based on the design rather than model assumptions. However, the lack of randomization and replication of IMWs may not allow their results to be easily generalized to other populations. Inference is made by virtue of a study design, a modeling process, or both. The approach may be mechanistic or merely associative, and it varies by spatial and temporal scale.

The status/trend, project-based, and watershed-scale approaches rely more on correlative data to try and make a case for causal inference. Correlation is used to rule out alternative hypotheses (note that we make our case as much if not more by disproving plausible alternatives as we do by showing that the data are consistent with a hypothesis). Although these approaches may allow robust inferences at small spatial scales (scales smaller than the population), inferences at the population scale are usually inferred from correlation. The following criteria are often used to demonstrate causation from correlative association approaches:

- *Strength of Association*—Measures the size of the change in performance measures associated with the incidence of treatments. In some respects, this is similar to gradient analysis. One can compare the percentage difference in average value of performance measures at locations that received treatments to those that did not.
- *Consistency of Association*—An association between performance measures and the treatment that is observed many times provides higher confidence than if no such consistency is observed.
- *Specificity of Association*—The association is only seen in the presence of the treatment (i.e., an observed change in the performance measures occurs after the onset of the treatment).
- *Temporality*—If the treatment causes some change, then the change must follow the onset of the treatment. Temporality is a particularly useful criterion, because it has the potential to discard explanations – either the treatment explanation or alternative ones.
- *Biological or Ecological Gradient*—If one can observe a distinct increase in the magnitude of effect with increasing intensity of the treatment, then there is further evidence of causality.

Given the uncertainty of maintaining the integrity of robust monitoring designs (e.g., BACI designs, IMWs, etc.), a combination of approaches seems appropriate. IMWs should be implemented wherever feasible (i.e., where the integrity of the design can be maintained for at least 12 years, or about three generations), while project-based and/or watershed-based monitoring in concert with status/trend monitoring should be implemented where institutional control is less feasible.

The implementation of this monitoring approach will require reforms to some of our existing monitoring programs that: 1) lack critical elements of experimental design; 2) lack sufficient institutional control to maintain the integrity of the monitoring design over a time period sufficient to generate reliable results; 3) are collecting data at the wrong spatial or temporal scales; 4) are collecting data without an analytical framework to evaluate and adapt restorations and monitoring actions; 5) are collecting data without using standardized monitoring protocols; and/or 6) are reporting data inconsistent with regional data sharing standards.

**Table 1.** Intrinsic and extrinsic constraints on methods to determine population scale biological effect of tributary habitat restoration actions.

| Monitoring Approach | Scale | | Type of Inference | | Certainty of Cause-and-Effect at Population Scale | Identify Mechanism (Action specific) | Sensitivity to Institutional Control | Notes |
|---|---|---|---|---|---|---|---|---|
| | Spatial | Temporal | Design Based (Test/Control) | Model Based (Correlational) | | | | |
| Status/Trend | Large (population, MPG, ESU) | Long (decades) | No | Yes | Low-Moderate | No | Low | Confounded by lack of controls, replicates, and multiple treatments |
| Bottom-Up (Project-based) | Small (but scaled to population indirectly) | Long (decades) | Yes at small scale. No at population scale. | No at small scale. Yes at population scale. | Low-Moderate | Yes at small scale. No at population scale. | Medium at small scale. Low at population scale. | Low priority, cheap, and does not provide population level answers |
| Top-Down (Watershed scale) | Watershed-Population | Short-Moderate | Yes at all scales. | No | High | Yes at small scale. No at population scale. | High | Confounded with multiple treatments, rare opportunities |
| IMW (with one or many action types) | Watershed-Population | Short | Yes at all scales. | No | High | Yes at all scales for one action. No at population scale for many actions | High | Difficult to implement, rare opportunities |

## Importance of Habitat Models

Not all tributary habitat actions can be monitored, nor can the effects of actions be measured for all populations. Therefore, analytical tools are needed to assess the potential effects of habitat actions on population productivity across the many populations that will be treated with habitat actions. Analytical tools range from the simple (professional-judgment-guided model of the Habitat Remand Workgroup) to the very complex (Ecosystem Diagnosis and Treatment model). The goal will be to develop a transparent model that can be applied across different landscapes and populations, and provides reasonably accurate results.

One model that is transparent and has provided reasonably accurate results, at least in the Puget Sound area, is the Shiraz model (Scheuerell et al. 2006). Shiraz relies on a multistage Beverton-Holt model to describe the production of salmon from one life stage to the next. It includes density-dependent population growth, habitat attributes, hatchery operations, and harvest management in a time-varying, spatially explicit manner. The fact that it deals with hatchery operations is important because many of the populations that will be treated with habitat actions have hatchery programs, some of which will be going through modifications. This model should allow researchers to examine the separate and combined effects of habitat and hatchery actions on population parameters.

It is important that habitat monitoring support the development of analytical tools. This means that monitoring should be conducted at spatial and temporal scales sufficient to develop and populate models and to provide data to validate the models. This can probably be accomplished by monitoring extensively a select few populations across the Columbia Basin.

Attachment 2 – Rationale for a Modeling Approach, provides additional information regarding the need and rationale to use a modeling approach to assess the population level effects of the PA habitat actions.

## Confounding Hatchery or Harvest Effects

Where hatcheries or terminal harvests are affecting tributary survival and productivity, the monitoring approach for habitat action effectiveness will need to appropriately account for and/or attempt to control these potential confounding factors. This may require attempts to maintain consistent hatchery or harvest effects over the life of the study to minimize confounding effects. Alternatively, an integrated, stratified research approach may need to be implemented that incorporates the habitat and the hatchery or harvest effects within the same research and monitoring design. The AA are currently supporting a model-based design to simultaneously serve habitat and hatchery information needs within the Integrated Status and Effectiveness Monitoring Project (ISEMP) population and habitat status and trend monitoring project proposed for implementation in the South Fork Salmon River SFSR) of Idaho. For more information on integrating hatchery and habitat action effectiveness studies, see the section "Integrating Habitat and Hatchery RME Efforts" in Appendix 5X Hatchery RM&E.

## Tributary Habitat RM&E Actions

The Action Agencies propose to implement the following actions to provide the necessary biological and environmental performance measures to answer key management questions and provide guidance for adaptive management decisions.

### Monitor and Evaluate Tributary Habitat Conditions and Limiting Factors

Habitat status monitoring and limiting factor analyses are primarily the responsibility of agencies affecting or regulating tributary habitat areas; however, given the importance of this information to the diagnosis and effective planning of offsite mitigation actions, and the application of these data in complimentary action effectiveness evaluations, Action Agencies are proposing the following targeted actions:

- *Implement research in select areas of the pilot study basins (Wenatchee, Methow and Entiat River Basins in the Upper Columbia, the Lemhi and South Fork Salmon River Basins and the John Day River Basin) to quantify the relationships between habitat conditions and fish productivity (limiting factors) to improve the development and parameterization of models used in the planning and implementation of habitat projects. These studies will be coordinated with the influence of hatchery programs in these habitat areas.*
- *Implement status and trend monitoring as a component of the pilot studies in the Wenatchee, Methow and Entiat River Basins in the Upper Columbia, the Lemhi and South Fork Salmon River Basins and the John Day River Basin.*
- *Facilitate and participate in an ongoing collaboration process to develop a regional strategy for limited habitat status and trend monitoring for key ESA fish populations and an associated regional MOU for joint funding and implementation. This monitoring strategy will be coordinated with the status monitoring needs and strategies being developed for hydro, habitat, hatchery, harvest and estuary/ocean.*

### Evaluate the Effectiveness of Tributary Habitat Actions

The Action Agencies will evaluate the effectiveness of habitat actions through RM&E projects that will support the testing and further development of relationships and models used for estimating habitat benefits. These actions follow the general monitoring approaches and adaptive modeling applications identified earlier for determining the effects of proposed habitat actions. These evaluations will be coordinated with hatchery effectiveness studies.

- *Action effectiveness pilot studies in the Entiat River Basin to study treatments to improve channel complexity and fish productivity.*
- *Pilot study in the Lemhi Basin to study treatments to reduce entrainment and provide better fish passage flow conditions.*
- *Action effectiveness pilot studies in Bridge Creek of the John Day River Basin to study treatments of channel incision and its effects on passage, channel complexity, and consequentially fish productivity.*
- *Project and watershed level assessments of habitat, habitat restoration and fish productivity in the Wenatchee, Methow and John Day Basins.*

See Table 2, Appendix 1X for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Tributary Habitat RM&E. Further information regarding the pilot studies in the Upper Columbia, John Day and Upper Salmon currently being implemented through the ISEMP project is provided as Attachment 3 to this appendix.

## Project Implementation and Compliance Monitoring

Tributary habitat projects will be monitored for implementation of planned deliverables and compliance to performance expectations. Implementation monitoring documents the type of habitat action, its location, and whether the action was implemented properly and completely or complies with established standards. It does not require collection of biological or environmental data. The AA will use PNAMP standards for project tracking to support regional coordination of project implementation tracking and effectiveness monitoring designs.

Implementation and compliance monitoring will answer two primary questions: (1) were the actions implemented completely and according to expected schedules and (2) were the actions implemented correctly.

- *The Action Agencies will monitor the successful implementation of projects through standard procedures and requirements of contract oversight and management, and review of project deliverables and final reports.*
- *The Action Agencies will maintain BiOp databases to provide fish improvement and monitoring project and action level details for planning and reporting purposes. This approach will provide the most up-to-date information about the status of actions and projects being implemented.*
- *The Action Agencies will use the project level detail contained in the Action Agencies' BiOp databases to track results and assess our progress in meeting programmatic level performance targets.*

## RM&E Coordination and Data Management

The Action Agencies will coordinate RM&E activities with other federal, state and tribal agencies, and will ensure that the information obtained under the auspices of the FCRPS RM&E efforts is archived in appropriate data management systems. See the RM&E Coordination and Data Management section of the RM&E PA for specific actions. Much of the RM&E coordination and data management related to tributary habitat will be carried out under the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), the Northwest Environmental Data-network and the Pilot Studies in the Upper Columbia, John Day and Snake River basins currently being implemented through the ISEMP project (see Attachment 3). Many of these products will be important to the advancement of more regionally shared and robust tributary habitat monitoring information.

The AA agencies are providing cost-share funding and participation in Steering Committee leadership and Workgroups within PNAMP. Products being developed and regionally coordinated under PNAMP include:

- Coordinate standards for regional project tracking to support implementation and effectiveness monitoring.
- Management questions "white paper" to facilitate coordination by identifying relative importance of management questions (and their related hierarchical set of information needs) shared by the PNAMP partners.
- High level indicators "white paper" to recommend a core set of indicators that can be shared among all types of monitoring.
- Standard macroinvertebrate field and laboratory sampling protocols.
- Habitat protocols recommendations (watershed assessment methods).
- Assist with the advancement of a regional information management strategy for fish and habitat data.
- Develop regional data dictionary for monitoring & protocol catalogue tool (Protocol Manager).
- Advance development of a regional Aquatic Monitoring Activity Inventory.
- Fish Protocols: Marking/Tagging Techniques Guidance.
- Fish Protocols: Develop protocol comparison tests and further advance the recently developed Salmonid Field Protocols Handbook.
- Monitoring Survey Design recommendation for a regional aquatic status & trends monitoring design (using the EMAP probabilistic GRTS design developed by the EPA).
- Effectiveness Protocols: facilitate adoption of standardized protocols across PNAMP partners
- Effectiveness Protocols: recommend strategy for implementation of the PNAMP-recommended network of Intensively Monitored Watersheds (IMW) and reach specific studies for effectiveness monitoring.
- Estuary Protocols: coordinate protocols for monitoring in estuaries.
- Facilitate application of remote sensing tools for aquatic monitoring.
- Identify and implement a process for developing/refining common GIS layers.

The AA agencies are providing cost-share funding and participation in Steering Committee leadership and Workgroups within NED. Products being developed and regionally coordinated under NED include:

- Develop and maintain a strategy to achieve improvements in regional data quality, quantity and access.
- Coordinate development and adoption of data stewardship responsibilities and data sharing agreements.
- Develop protocols to provide access to regional data networks, and management systems as they become available, for fish and wildlife and their aquatic and terrestrial habitat and water data via the world wide web.
- Maintain and populate a Web based Pilot Data Portal.
- Pilot a Distributed Database Management System for Salmonid Abundance and Trend data and link to water quality data.
- Develop a draft Best Practices for Salmonid Trend and Abundance Data Quality Assurance and Quality Control.
- Pilot a Regional Data Recovery Effort to capture and integrate existing regional fish and habitat data.

The AA agencies are providing funding for the development of a pilot data management system for monitoring data under ISEMP. Associated products being developed and regionally coordinated include:

- Monitoring strategy for the Upper Columbia Basin.
- Develop, test, and document indicators and metrics of status, trend, and effectiveness.
- Upper Columbia monitoring protocols for habitat, smolt trapping, snorkeling, electro fishing, water quality, spawning ground, PIT tag deployment and detection, and macroinvertebrate data collection.
- Integration and testing of Protocol Manager, a protocol catalogue tool.
- Site Manager tool to support integration and tracking of regional monitoring sites.
- Data entry templates to facilitate data documentation, entry, validation, summarizing, reporting, and submission to central warehouses.
- Standardized database schema that integrates fish, habitat, and water quality data.
- Central data warehouse for spatial and tabular monitoring data.
- Web-based interface for viewing and downloading both raw and summarized monitoring data.
- Implementation and testing of monitoring survey designs including the GRTS survey design developed by the EPA.
- Current and historic monitoring data layers for Wenatchee, John Day, and Salmon sub-basins.
- Data analysis framework for monitoring data in Wenatchee, John Day, and Salmon sub-basins.

# Attachment 1

# Approach to Estimating Survival Benefits of Habitat Actions

**March 27, 2007**

Over the decade many books on salmon conservation have emerged (e.g., NRC 1996; Stouder et al. 1997; Lichatowich 1999; Knudsen et al. 2000; Lynch et al. 2002; Montgomery et al. 2003; Wissmar and Bisson 2003), and all agree that habitat restoration should be a cornerstone of any recovery program. As such, it is important to identify locations where current habitat conditions would benefit from protection or restoration. In addition, it is also important to assess the potential benefits of habitat actions to target fish populations and ESUs.

Estimating potential biological benefits (e.g., increased survival or productivity) is a difficult task because most habitat actions do not affect biological parameters directly. The usual approach is to manipulate the environment (add wood, rock, vegetation, nutrients, passage, etc.) in the hope that the change in the environment will result in a desired change in the population (biological parameters). For example, one may add woody debris to a stream to increase the abundance and survival (productivity) of juvenile Chinook in a stream reach. In the chain-of-causation, the "cause" is the addition of wood (treatment), which directly "affects" the stream environment (presence of woody debris is the first link in the chain). The presence of woody debris should then "affect" the abundance and survival of juvenile Chinook (biological response is the second link). Note that abundance and survival of Chinook (biological response) is more than one link from the treatment (Figure 1).

## Chain of Causation

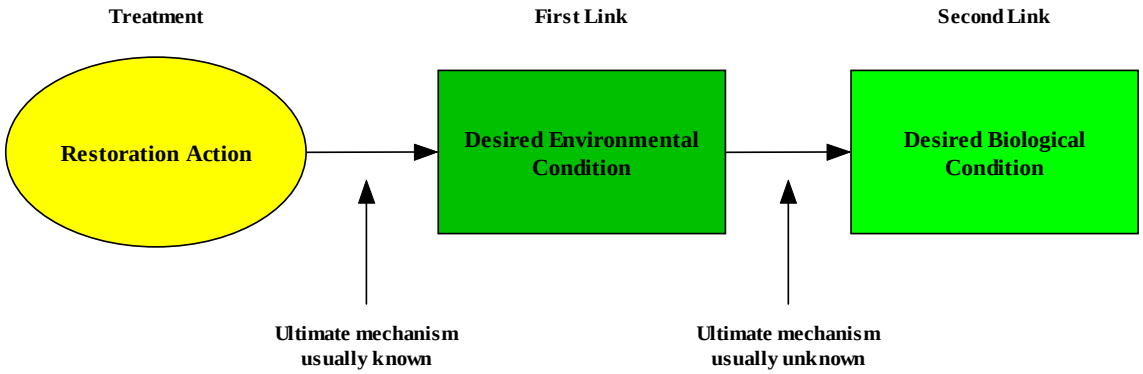


**Figure 1.** Conceptual model showing the chain-of-causation from the restoration action (treatment) to the environmental and biological responses. The mechanism(s) resulting in a biological change is less well understood as more links are added to the chain.

As a general rule, the more links there are between the treatment and desired effect, the more difficult it will be to detect or predict a treatment effect. Stated another way, the more links between the treatment and the desired effect, the less confidence one has that the treatment will actually result in a desired effect. This is because several other factors (extraneous or nuisance factors) may have a greater effect on the desired outcome than the treatment. For example, it is unlikely that one can predict with any confidence what affect rock weirs will have on the abundance and productivity of adult Chinook within a stream. Not only is adult abundance several links removed from the treatment, Chinook, like other anadromous species, use multiple ecosystems (tributary, mainstem, estuary, ocean systems) that are each replete with extraneous factors acting upon the survival of the fish (Figure 2). As the number of links between the action and the desired response increase, the number of extraneous factors increases making predictions about biological responses uncertain.

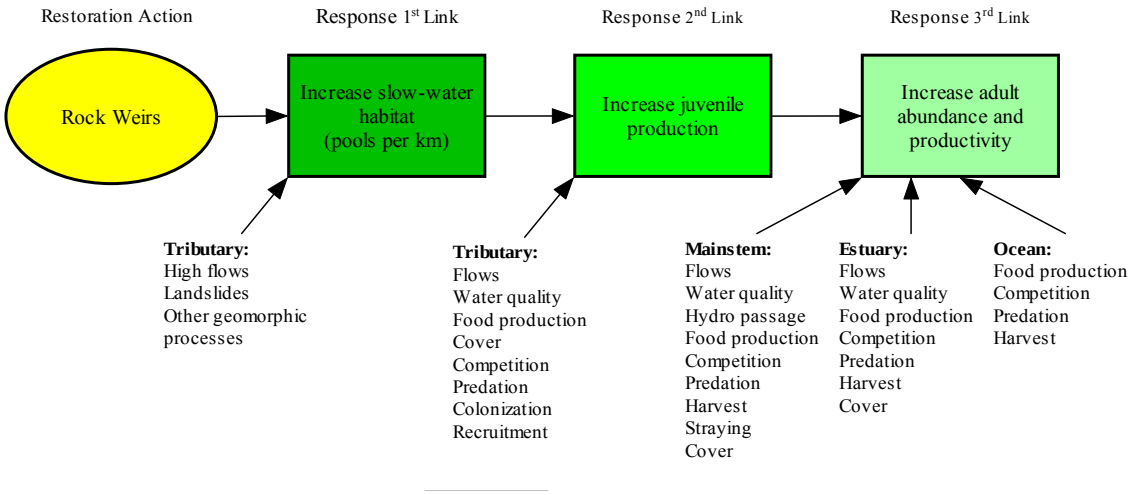


**Figure 2.** Relationship between a restoration action (rock weirs) and physical and biological responses. As the number of links increase, the number of extraneous factors (those listed below the causal chain) increase, making it more difficult to identify a treatment effect. The ability to predict desired outcomes decreases as more links are added to the chain (reflected in the decreasing shades of green).

For these reasons, it is very difficult to estimate with any certainty the potential benefits of habitat actions on adult abundance or productivity. Therefore, the Habitat Workgroup estimated survival benefits for only two life-stages, juvenile and pre-spawning adult.

There were two general approaches that the Habitat Workgroup explored: (1) life-cycle models and (2) professional judgment (similar to the Appendix E approach used in the 2004 BiOp). The workgroup considered models such as EDT, HQI, HEP, PHABSIM, Shiraz, and a simple model developed by CRITFC. One model, EDT, has been used by some recovery planning groups to estimate survival benefits associated with recovery actions. Although the model was used to generate hypotheses in draft recovery plans, it is very complex, relies on many assumptions, and requires considerable input based on empirical data, derived data, and/or professional judgment. In addition, outputs lack confidence limits and therefore sensitivity analysis is needed to estimate certainty. Populating and running the model is time-consuming. Other models (e.g., HQI, HEP, PHABSIM, and Shiraz) can be used to generate hypotheses about potential benefits, but, like EDT, these tools require significant input and time to run. Given the lack of time and information

or data, such analytical tools or models were not an option in the Remand Process. The workgroup did use results from models used in other forums (e.g., recovery plans and subbasin plans).

The second approach relied on professional judgment. This method was deemed the most reasonable approach given the lack of time and information available. This approach relied heavily upon the expertise of local biologists. Local biologists with the most knowledge about local watershed processes, habitat conditions, and fish populations in their respective areas provided the workgroup with estimates of current habitat conditions, primary limiting factors, restoration actions needed to fix limiting factors, and potential habitat conditions that would result if the primary limiting factors were addressed.

In an attempt to standardize the habitat assessment process, the Habitat Workgroup provided local biologists with a guidance document and standardized matrices to aid in estimating current conditions, limiting factors, restoration actions, and potential habitat conditions. Local biologists, with guidance from the Habitat Workgroup, populated the habitat matrices. Data within these matrices were used by the Habitat Workgroup to estimate overall habitat quality and potential survival benefits associated with implementing proposed tributary habitat actions.

## Estimating Habitat Quality

Habitat quality is dependent on more than one habitat variable (e.g., stream flows, temperature, water quality, fine sediments, pools, woody debris, off-channel habitat, etc.). Local biologists provided the Habitat Workgroup with estimates of current and potential conditions[1] for each habitat variable that was currently limiting fish productivity. The workgroup then combined the condition scores for each individual variable into a composite habitat quality score. The workgroup evaluated several different methods for combining conditions of individual habitat variables to obtain a composite score.

(1) The first method was multiplication (i.e., multiply the individual habitat scores to obtain a composite score). This method assumes that fish select each particular habitat variable independently of other variables (assumes no interaction or compensation). One problem with this method is that the product equation yields zero habitat quality for any given habitat variable of unsuitable condition. For example, a stream reach with no woody debris (0% function) would result in a composite habitat quality score of 0%.

(2) The second approach used the lowest condition habitat variable as the composite habitat quality score. This assumes that the most limiting factor (habitat variable with the lowest condition score) determines the upper limit of habitat quality and the fact that variables with high condition cannot compensate for low condition variables.

(3) The third approach was the geometric mean of individual habitat scores. This method provides some compensation, but like the product equation, it yields zero habitat quality for any zero-valued habitat variable.

[1] Current and potential conditions were given as percentages of optimal conditions. NOAA Fisheries definition of properly functioning condition (PFC) was used to help local biologist understand what was meant by optimal condition (see NMFS 1996).

(4) The final approach was the arithmetic mean of individual habitat scores. This approach assumes that good habitat conditions on one variable can compensate for poor conditions on other variables.

After evaluating these methods, the Habitat Workgroup concluded that a combination of the second and fourth approaches was reasonable. The second method was used when a limiting habitat variable was considered a lethal factor. Lethal factors included variables that at certain concentrations or levels kill fish (e.g., temperature and other water quality parameters, fine sediment, flows, etc.).[2] Thus, overall habitat quality was based only on the condition of the lethal factor if its concentration was at a level that would kill fish. The arithmetic mean (fourth approach) was used if no lethal factors were identified by the local biologists.

Following this exercise, the Habitat Workgroup then identified "functional relationships" that would aid in estimating potential survival benefits corresponding to projected changes in habitat quality. The intent was to find a simple function or functions that would allow the workgroup to estimate how much juvenile or pre-spawning adult survival would increase if habitat quality improved from, say, 35% to 45% of optimal condition. The functional relationships were only used to guide professional judgment in estimating potential survival increases. They were not developed to estimate "absolute" survival rates.

## Identification of Functional Relationships

Not knowing if the "shape" of the relationship between habitat quality (as a percent of optimal condition) and survival was linear or non-linear, the Habitat Workgroup began by exploring existing life-cycle models in search of common relationships that could be used to guide professional judgment. Examination of relationships in EDT was difficult, because of the complexities of the model. The workgroup found no simple functions in EDT that could be used to guide professional judgment. On the other hand, the Shiraz model (Scheuerell et al. 2006) and work by McHugh et al. (2004) were more transparent and provided analytical relationships between habitat attributes and survival. These models included relationships for temperature, fine sediment (embeddedness), flows, and cover (cobbles and wood) for different juvenile life stages and for pre-spawning adults. Listed below are relationships between survival and habitat attributes for different life stages.

[2] In contrast, controlling factors include variables that do not directly kill fish but can affect their abundance and distribution (e.g., number of pools, off-channel habitat, woody debris, etc.). These variables were averaged to estimate overall habitat quality.

### *Incubation*

Scheuerell et al. (2006) described the following hockey-stick relationship between temperature and egg-fry survival based on data in Tappel and Bjornn (1983):

$$p_{1,2} = \begin{cases} 0.95 & \text{if } f < 0.268 \\ -3.32 f + 1.81 & \text{if } 0.268 \le f < 0.544 \\ 0.06 & \text{if } f \ge 0.544 \end{cases}$$

This function relates survival ($p_{1,2}$) to the percentage of fine sediment ($f$ < 6.35 mm) within spawning and incubation habitat. If fines less than 1.7 mm are used, the following relationship applies:

$$p_{1,2} = \begin{cases} 0.93 & \text{if } f < 0.116 \\ -5.21 f + 1.54 & \text{if } 0.116 \le f < 0.283 \\ 0.06 & \text{if } f \ge 0.283 \end{cases}$$

McHugh et al. (2006) provided an alternative survival function based on data in Stowell et al. (1983) and Tappel and Bjornn (1983).

$$p_{1,2} = [92.95 / (1 + e^{-3.994+0.1067*\text{fines}})]/100$$

This relationship is based on fine sediments in spawning gravels less than 6.35 mm in diameter.

Scheuerell et al. (2006) described the following relationship between water temperature ($T_{inc}$) and egg-fry survival ($p_{1,2}$):

$$p_{2,1} = \begin{cases} 0.273 T_{inc} - 0.342 & \text{if } 1.3 \le T_{inc} < 4.7 \\ 0.94 & \text{if } 4.7 \le T_{inc} < 14.3 \\ -0.245 T_{inc} + 4.44 & \text{if } 14.3 \le T_{inc} < 18.1 \\ 0.01 & \text{if } T_{inc} \ge 18.1 \end{cases}$$

McHugh et al. (2004) described an alternative survival rate function for egg-fry survival.

$$p_{1,2} = -0.26 + 0.27(T_{inc}) - 0.02(T_{inc})^2$$

Scheuerell et al. (2006) described the following relationship between normalized flow (Q*) and egg-fry survival ($p_{1,2}$):

$$p_{2,2} = \begin{cases} 0.58 - 0.844 Q^* & \text{if } Q^* < 0.675 \\ \\ 0.01 & \text{if } Q^* \ge 0.675 \end{cases}$$

### *Summer Rearing*

McHugh et al. (2006) provided the following functional relationship using a polynomial function reported in Stowell et al. (1983) based on the work of Bjornn et al. (1977).

$$S = [100 - 1.79(\text{Emb}) + 0.0081(\text{Emb})^2]/100$$

The function relates percentage summer stream capacity to the degree (%) that cobbles are embedded in riffle/run habitat.

McHugh et al. (2004) described the following relationship between water temperature and survival of Chinook parr during summer rearing:

$$S = \exp\left\{-\left[\left(\frac{sumT}{27.0271}\right)^{10.74}\right]\right\}$$

This function was computed using a Weibull function that related daily survival (*S*) to mean daily stream temperature (*sumT*) for any given day of the summer rearing period. Using this function, the daily survival rate decreases whenever the average daily temperature exceeds an upper temperature threshold of 17.8 °C.

***Winter Rearing***

McHugh et al. (2006) provided the following relationship using a function reported in Stowell et al. (1983) based on the work of Bjornn et al. (1977).

$$S = 1.001e^{-0.013(\text{Emb})}$$

This exponential function relates overwinter capacity for Chinook parr to percent pool embeddedness (Emb).

Cramer (2001) described the following relationship between percentage of cobbles and wood in pools (<15%) and overwinter survival of Chinook parr:

$$S = 20 + [80(\text{Cob})/15]/100$$

***Pre-Spawning Adult***

Cramer (2001) provided the following relationship for pre-spawner adult Chinook salmon:

$$p_1 = \begin{cases} 1 & \text{if } T_{pre} < 16 \\ 1 - 0.15(T_{pre} - 16) & \text{if } 16 \le T_{pre} < 22.6 \\ 0.01 & \text{if } T_{pre} \ge 22.6 \end{cases}$$

This function relates adult survival ($p_1$) to mean maximum temperatures ($T_{pre}$) during migration and pre-spawning.

These functions describe relationships between specific habitat attributes (e.g., temperature, fine sediment, etc.) and survival. However, local biologists provided habitat quality data scaled from 0% to 100% of optimal condition. Therefore, it was necessary to transform the habitat attributes into a common habitat quality index that ranged from 0-100%; where 0% habitat quality

represented the worst habitat condition (lethal sediment levels and temperatures) and 100% habitat quality represented the best habitat condition (optimal temperature and sediment levels). These habitat quality ratings of 0-100% equated to survival indices that ranged from 0.0 to 1.0, respectively. In this case the survival index has no connection with "absolute" survival rate. That is, one cannot determine the absolute egg-smolt survival rate from these relationships. In contrast, the functions can be used to estimate possible survival increases associated with habitat actions if the ratio of the survival index under improved habitat conditions (potential survival index; $S_{rp}$) to the survival index under current conditions ($S_{rc}$) equals the ratio of potential absolute survival ($S_{ap}$) to current absolute survival ($S_{ac}$).

$$S_{rp} / S_{rc} \approx S_{ap} / S_{ac}$$

Thus, an estimated survival index ratio of 1.2, calculated as the ratio of the potential survival index of 0.30 to the current survival index of 0.25, implies that the absolute survival rate would increase approximately 20% if habitat restoration actions were implemented. If the current absolute survival rate is 0.08[3], the expected potential survival rate would increase about 20% to 0.10. In this exercise the workgroup is more concerned with the ratio than with the absolute survival values.

The workgroup plotted the relationships in an effort to find a common "shape" among the functions (Figure 3). It was clear that no "common" functional relationship existed within or among life stages. Therefore, the workgroup tried to combine relationships in an attempt to find a shape of central tendency.[4] The workgroup explored several different approaches: (1) average across all survival functions, (2) average survival functions within a life stage and multiply the mean functions across life stages, (3) multiply across all survival functions, and (4) use a simple linear function. These relationships are shown in Figure 4.

[3] For many populations, absolute survival rates for juvenile Chinook are unknown. Calculating ratios of survival indices appears to be a useful alternative in the absence of absolute survival rates. This is based on the assumption that ratios of survival indices represent ratios of absolute survival rates.

[4] It is important to note that there are several problems with generating functions of central tendency. For example, absolute survival rates cannot be estimated, information is lost by converting habitat attributes into habitat quality ratings, and combining functions provides false precision and accuracy. However, the intent was simply to identify a functional shape that would guide professional judgment. The function was not developed to estimate absolute survival rates.

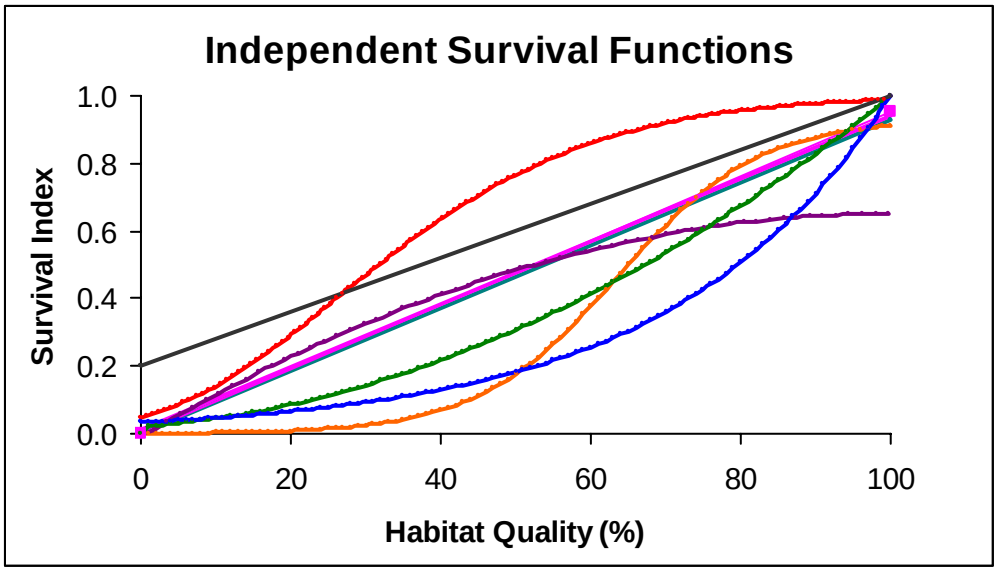


**Figure 3.** Various shapes of functional relationships between habitat quality and survival index.

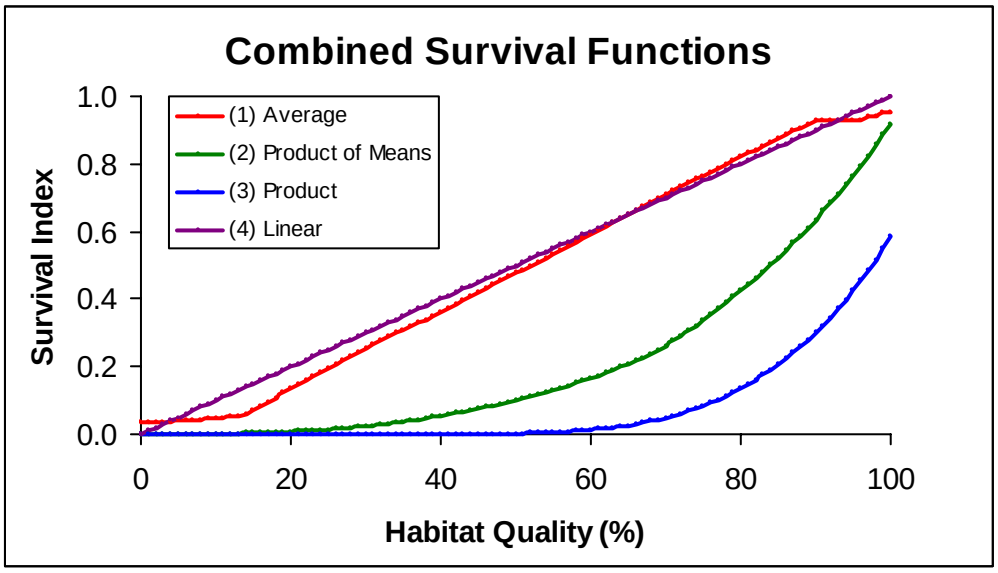


**Figure 4.** Comparison of shapes of functions generated by seeking relationships of central tendency.

Each of the "combined" functions was then evaluated by calculating potential survival gains associated with habitat quality data provided by local biologists. Where possible, estimated survival increases were compared with EDT results, historic redd counts, and/or survival benefits identified in the Human Impacts Report (from the Framework Workgroup). Both the linear function and the average function (based on median scores) provided estimates closest to EDT results and estimates contained in the Human Impacts Report. The exponential functions grossly overestimated survival benefits (in some cases they estimated well over 10,000 fold increases in juvenile survival). The workgroup found no biological reason why the average function was the most appropriate relationship. There is no justification why there would be little survival increase

associated with habitat quality increases from 0-10% and 90-100%. The workgroup collectively agreed, given the current data, that the linear function was the most realistic and should be used to guide professional judgment. This relationship also fits well with published literature that indicates that more intensive and extensive restoration actions result in greater survival benefits (e.g., see Paulsen and Fisher 2001).

To avoid the misconception that juvenile survival could be near 100% (survival index of 1.0) at high habitat quality, the Habitat Workgroup converted the survival indices into survival rates that represented actual juvenile and adult survivals measured in natural environments. The workgroup then developed different linear functions for Chinook salmon, steelhead, and chum salmon based on these actual survival rates. The goal was to identify what egg-smolt survivals for naturally produced Chinook salmon and steelhead and egg-fry survivals of chum salmon corresponded to optimal habitat conditions (100% habitat quality under natural conditions). The following is a brief summary of egg-smolt and egg-fry survival estimates that were readily available.

### *Chinook Salmon*

Some of the highest Chinook survival rates were reported by Bugert and Seidel (1988) in the Tucannon River. Using a migrant trap on the lower Tucannon River, Bugert and Seidel (1988) estimated an egg-smolt survival that ranged from 13-22% between 1985 and 1987. In the Yakima River, Major and Mighell (1969) estimated that 5.4-16.4% of the potential spring Chinook egg deposition survived to migrate as yearling smolts. Later work by Fast et al. (1989) indicated that, on average, 4.94% (range, 4.2-6.5%) of the eggs survived to migrate as smolts in the Yakima River. In the John Day River, egg-smolt survivals of spring Chinook were estimated as 3.6-8.6% (Knox et al. 1984), while Lindsay et al. (1989) reported spring Chinook survivals of 2.1-8.7% in the Deschutes River.

In the Methow, Wenatchee, and Entiat systems, Mullan et al. (1992) estimated egg-smolt survivals of 1.35-2.15%, 1.55-2.35%, and 2.90-6.65%, respectively, for spring Chinook. Mullan et al. (1992) calculated these survivals by extrapolating rearing densities for the total basin rearing areas by habitat quality index ranking with an assumed 40% overwinter survival. In the Chiwawa Basin, WDFW (unpublished data) has estimated egg-smolt survivals for spring Chinook brood years 1991-2003. They estimated an average egg-smolt survival of 8.6% (range, 3.7-16.9%). Quinn (2005) recently reviewed published and unpublished estimates for wild or naturally produced Chinook populations and reported a mean egg-smolt survival of 10.4%.

### *Steelhead*

Ward and Slaney (1993) conducted a thorough study of steelhead egg-smolt survival for seven years in the Keogh River, B.C. and estimated a mean survival of 0.51% (range, 0.28-1.30%). Bley and Moring (1988) described a study that was conducted by the WDW Snow Creek Research Station in Washington. Using winter steelhead, WDW estimated an egg-smolt survival of 1.6%. Bjornn (1978) reported that survival of steelhead from egg-smolt in the Lemhi River ranged from 0.16-3.61%. WDF et al. (1990) estimated an egg-smolt survival of 1.7% for steelhead in the Wenatchee River. In contrast, Peven (1992) repored a survival of 0.4%. Peven's estimate included the entire mid-Columbia basin.

Thurow (1987) reviewed egg-smolt survival rates for wild steelhead. He found that rates ranged from 0.5-2.5%. Most of the work reported for seven river systems indicated survivals from 1-2%

(Bjornn 1978; Phillips et al. 1981; WDG 1983). Thurow (1987) assumed survival of 1% under poor spawning conditions (e.g., poor quality spawning habitat, abnormal flows, abnormal temperature regimes, and redd superimposition), 1.5% under average conditions, and 2% under optimal conditions in the South Fork Salmon River. Quinn's (2005) review of published and unpublished estimates for wild or naturally produced steelhead populations indicated a mean egg-smolt survival of 1.4%.

***Chum Salmon***

Salo (1991) summarized egg-fry survival rates of chum salmon in his Tables 10 and 11. His summary indicates that egg-fry survivals of naturally produced chum salmon in natural environments can range from 0.1 to 85.9%. The latter is an estimate of survival of chum in the Iski River (tributary to the Amur River in Russia). This estimate appears to be an outlier when compared to estimates from other systems. Most survival estimates were less than 35%. Quinn's (2005) review indicated a mean egg-fry survival of 12.9% for chum salmon.

Based on this review of readily available literature, the following egg-smolt and egg-fry survival estimates appear reasonable if one assumes optimal (100% habitat quality) spawning and rearing conditions:

Chinook Salmon: 18% egg-smolt survival

Steelhead: 4% egg-smolt survival

Chum Salmon: 35% egg-fry survival

These estimates represent the highest survivals that could be achieved under optimal habitat conditions. The workgroup also assumed that the maximum pre-spawning adult survival would be 100% at optimal conditions. It is important to note that some systems may never achieve these life-stage survivals, because the systems are naturally unable to establish conditions that would be "optimal," even if all anthropogenic effects could be removed.

Applying these maximum survival rates to optimal habitat conditions resulted in linear functions with different slopes (rates of change) for each species and life stage (Figure 5). The Habitat Workgroup used the following linear functions to guide professional judgment in estimating survival improvements associated with habitat quality improvements:

Chinook salmon egg-smolt survival = 0.0018*(Habitat Quality)

Steelhead egg-smolt survival = 0.0004*(Habitat Quality)

Chum salmon egg-fry survival = 0.0035*(Habitat Quality)

Adult pre-spawning survival = 1.0*(Habitat Quality)

These functions provided a conservative approach to estimating survival gains and resulted in estimates that were generally less than those calculated with EDT.

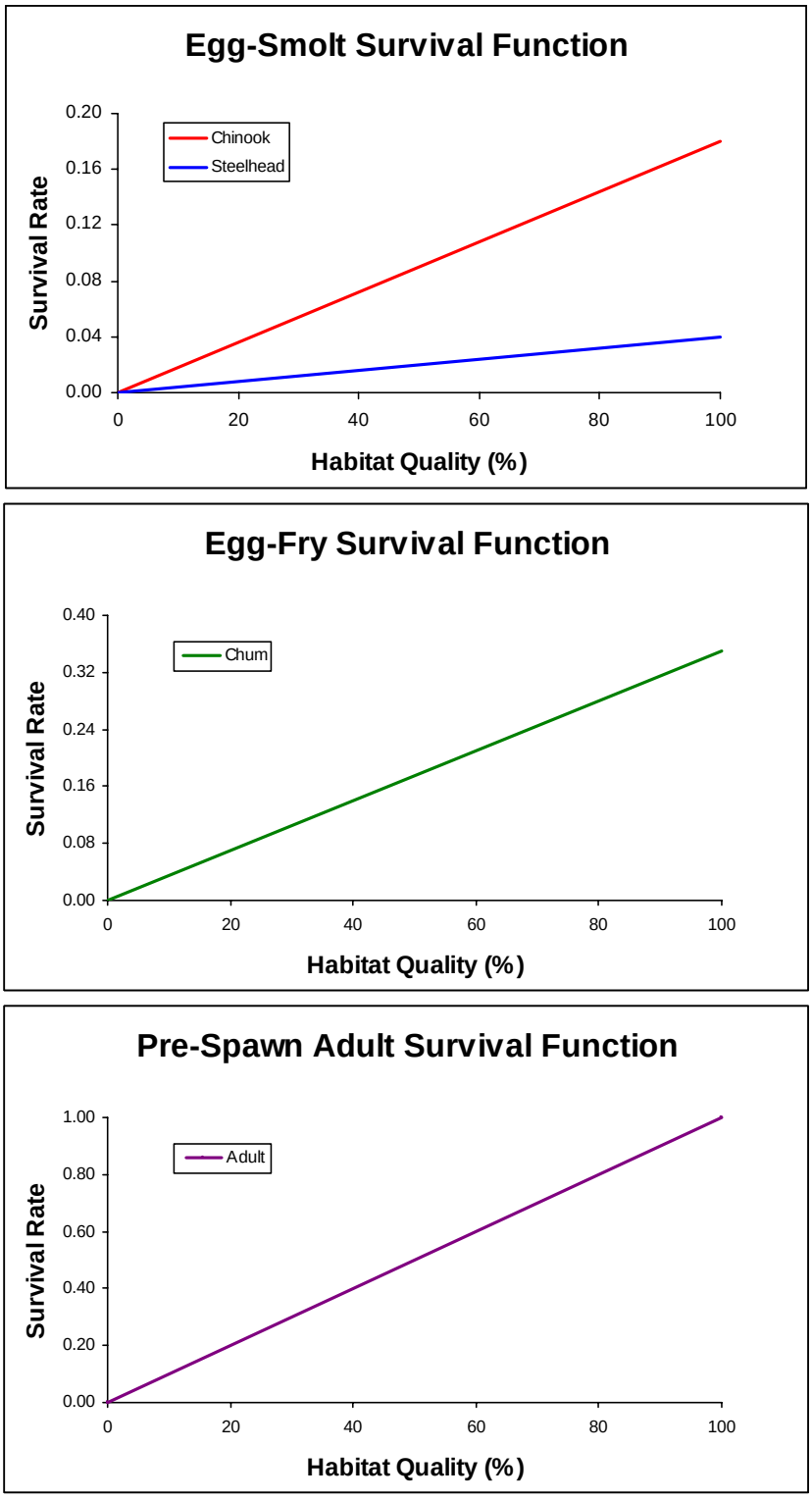


**Figure 5.** Linear functions for egg-smolt, egg-fry, and pre-spawning adult survival of Chinook salmon, chum salmon, and steelhead.

## Estimating Survival Changes within Assessment Units

Local biologists have subdivided the geographic areas of some populations into smaller assessment units (AUs) or watersheds. Within these smaller units, they described current habitat conditions (as a percent of optimal conditions), identified primary limiting factors, proposed restoration actions that would address limiting factors, and estimated the potential habitat condition (as a percent of optimal condition) that would result if restoration actions were implemented. These habitat conditions within AUs were translated into relative survival estimates using the linear relationships described above. Current and potential survival rates were estimated based on current and potential habitat conditions. Potential survival rates were based on habitat conditions that could be achieved if actions were implemented within each AU.

Because different AUs within a population have different capacities and/or production potentials, survival estimates for those AUs were weighted according to their capacities or production potentials. Weightings were based on the fraction of the population that spawns within each AU or on the fraction of the total geographic area of the population that was contained in each AU. For example, if a given population had three AUs and one unit supported 65% of the spawners, another supported 10%, and the last supported 25% of the spawners, then AU1 was given a weight of 0.65, AU2 a weight of 0.10, and AU3 a weight of 0.25. Survival estimates for each AU were then multiplied by their respective weights to estimate a weighted survival rate. These weighted rates were added together to estimate the overall survival rate for the juvenile (tributary) life-stage of the population.

Overall current and potential survival estimates for the population were calculated separately. That is, current and potential survival estimates for each AU were multiplied by there respective weights and summed independently of each other. Once the workgroup had calculated the current and potential survival estimates for the population, the survival increase associated with habitat restoration actions was calculated simply as the ratio of the potential survival estimate for the population ($S_p$) to the current survival estimate for the population ($S_c$). That is,

$$S = S_p / S_c$$

The Habitat Workgroup reported these ratios as the survival improvements associated with habitat restoration actions.

## References

Bjornn, T. C. 1978. Survival, production, and yield of trout and Chinook salmon in the Lemhi River, Idaho. University of Idaho, Forest, Wildlife, and Range Experiment Station Bulletin 27, Moscow, ID.

Bjornn, T. C., M. A Brusven, M. P. Molnau, R. A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on aquatic life. University of Idaho, Forest, Wildlife, and Range Experiment Station Bulletin 17, Moscow, ID.

Bley, P. W. and J. R. Moring. 1988. Freshwater and ocean survival of Atlantic salmon and steelhead: a synopsis. U.S. Fish and Wildlife Service Biological Report 88(9).

Bugert, R. and P. Seidel. 1988. Production and survival of juvenile spring Chinook salmon in a southeast Washington stream. Pages 156-164 *in*: B. G. Shepard, ed. Proceedings of the Chinook/coho workshop. North Pacific International Chapter, American Fisheries Society.

Cramer, S. P. 2001. The relationship of stream habitat features to potential for production of four salmonid species. Final report to the Oregon Building Industry Association. S. P. Cramer and Associates, Gresham, OR.

Fast, D., J. Hubble, and B. Watson. 1989. Yakima River spring Chinook—the decline and recovery of a mid-Columbia natural spawning stock. Pages 18-26 *in*: B. G. Shephard, ed. Proceedings of the 1988 Northeast Pacific Chinook and coho salmon workshop. North Pacific International Chapter, American Fisheries Society.

Knox, W. J., M. W. Flesher, R. B. Lindsay, and L. S. Lutz. 1984. Spring Chinook studies in the John Day River, John Day salmon studies. Oregon Department of Fish and Wildlife, Research Division, Annual Report, FY 1984. Prepared for Bonneville Power Administration, Division of Fish and Wildlife, Project No. 79-4, Contract No. DE-AC79-84BP39796, Portland, OR.

Knudsen, E. E., C. R. Steward, D. D. MacDonald, J. E. Williams, and D. W. Reiser. 2000. Sustainable fisheries management: Pacific salmon. Lewis Publishers, New York, NY

Lichatowich, J. A. 1999. Salmon without rivers. Island Press, New York, N.Y.

Lindsay, R. B., B. C. Jonasson, R. K. Schroeder, and B. C. Cates. 1989. Spring Chinook salmon in the Deschutes River, Oregon. Oregon Fish and Wildlife Information Report No. 89-4, Portland, OR.

Lynch, K. D., M. L. Jones, and W. W. Taylor, editors. 2002. Sustaining North American Salmon: perspectives across regions and disciplines. American Fisheries Society, Bethesda, MD.

Major, R. L. and J. L. Mighell. 1969. Egg-to-migrant survival of spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Yakima River, Washington. Fisheries Bulletin 67:347-359.

McHugh, P., P. Budy, and H. Schaller. 2004. A model-based assessment of the potential response of Snake River spring-summer Chinook salmon to habitat improvements. Transactions of the American Fisheries Society 133:622-638.

Montgomery, D. R., S. Bolton, D. B. Booth, and L. Wall, editors. 2003. Restoration of Puget Sound rivers. University of Washington Press, Seattle, WA.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. U.S. Fish and Wildlife Service Monograph I, Leavenworth, WA.

National Marine Fisheries Service (NMFS). 1996. Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale. The National Marine Fisheries Service, Environmental Technical Services Division, Habitat Conservation Branch, Seattle, WA.

NRC (Nation Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. Nation Academy Press, Washington, D.C.

Paulsen, C. M. and T. R. Fisher. 2001. Statistical relationship between parr-to-smolt survival of Snake River spring-summer Chinook salmon and indices of land use. Transactions of the American Fisheries Society 130:347-358.

Peven, C. M. 1992. Population status of selected stocks of salmonids from the mid-Columbia River Basin. Chelan County Public Utility District, Wenatchee, WA.

Phillips, C. R. Cooper, and T. Quinn. 1981. Skagit River salmonid studies. Washington Department of Game and U.S. Fish and Wildlife Service, Olympia, WA.

Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press, Seattle, WA.

Salo, E. O. 1991. Life history of chum salmon (*Oncorhynchus keta*). Pages 231-310 *in*: C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver, Canada.

Scheurerell, M. D., R. Hilborn, M. H. Ruckelshaus, K. K. Bartz, K. M. Lagueux, A. D. Haas, and K. Rawson. 2006. The Shiraz model: a tool for incorporating anthropogenic effects and fish-habitat relationships in conservation planning. Canadian Journal of Fisheries and Aquatic Sciences 63:1596-1607.

Stouder, D. J., P. A. Bisson, and R. J. Naiman, editors. 1997. Pacific salmon and their ecosystems; status and future options. Chapman and Hall, New York, N.Y.

Stowell, R., A. Espinosa, T. C. Bjornn, W. S. Platts, D. C. Burns, and J. S. Irving. 1983. Guide for predicting salmonid response to sediment yields in Idaho batholith watersheds. U.S. Forest Service, Missoula, MT.

Tappel, P. D. and T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Thurow, R. 1987. Evaluation of the South Fork Salmon River steelhead trout fishery restoration program. Completion Report. Idaho Department of Fish and Game, U.S. Fish and Wildlife Service Contract 14-16-0001-86505, Boise, ID.

Ward, B. R. and P. A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence of Keogh River steelhead trout. Pages 209-217 *in*: R. J. Gibson and R. E. Cutting, eds. Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Canadian Special Publication of Fisheries and Aquatic Sciences 118.

Washington Department of Fisheries (WDF), Confederated Tribes and Bands of the Yakima Indian Nation, Confederated Tribes of the Colville Reservation, and Washington Department of Wildlife. 1990. Columbia basin system planning salmon and steelhead production, Wenatchee River Subbasin. Northwest Power Planning Council, Portland, OR.

Washington Department of Game (WDG). 1983. Memorandum to all treaty tribes and other concerned parties re: 1983-84 winter run steelhead harvest management. Washington Department of Game, Olympia, WA.

Wissmar, R. C. and P. A. Bisson. 2003. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and managed systems. American Fisheries Society, Bethesda, MD.

# Attachment 2

## Rationale for a Modeling Approach

The direct programmatic assessment of a suite of tributary habitat restoration actions will be difficult, if not impossible on the scale of the Interior Columbia River basin or even a single anadromous salmonid ESU. However, predicting the biological effect of these actions would be possible through a combination of models -- to generate hypotheses and experiments -- and data collection -- to test these hypotheses. Therefore, the Research, Monitoring and Evaluation program for the tributary off-site mitigation actions resulting from the FCRPS Biological Opinion will be structured as a series of monitoring actions to refine a programmatic modeling approach that predicts the biological benefit of the complete suite of activities covered by the Proposed Action.

Why not directly measure the biological benefit of the tributary habitat restoration actions covered by the FCRPS PA? A disparate suite of actions scattered across a wide range of ecoregions and ESUs will be difficult, if not impossible to assess in a programmatic fashion, particularly if the response variable is population productivity or life-stage specific survival.

1. Adding monitoring after-the-fact to reach scale habitat restoration projects will not be feasible on the scale of the Columbia River basin.

    --On the scale of the Columbia River basin reach scale habitat restoration projects will fall in watersheds across 10 ecoregions and represent 8 broad classes or types of restoration actions. Thus, to monitor the suite of possible actions will require stratifying actions by type and ecoregion, resulting in a total of 80 combinations of ecoregion x action-type. Even minimal sample sizes (n=10) for project types stratified by ecoregion will require the monitoring of 800 projects that conveniently fall in a balanced fashion across 80 categories. Since the constraint of balancing project type and ecoregion was not applied to select projects, the 800 projects will have to be drawn as a sub-set from a larger set of projects to create a balanced design. However, since there are fewer than 800 projects considered in the PA, it will not be possible to directly monitor, on the scale of the Columbia River basin, the programmatic effect of the PA.

2. Adding monitoring after-the-fact to reach scale habitat restoration projects is not likely to result in measurable benefits at the scale of individual projects.

    --Adding effectiveness monitoring after the fact to reach scale habitat restoration projects means that the monitoring will be designed to test if the treated reach is different from a carefully chosen control reach. Due to naturally occurring spatial

variation in physical and biological descriptors of habitat condition, sample size estimates for treatment-control pairings of habitat restoration actions at the reach-scale suggest that very large samples are required to detect treatment caused differences: sample sizes on the order of n=100. With sample sizes this large it is unlikely that the pool of replicate treatments and controls can be developed such that the 200 sites required for each action type are similar enough not to result in further increases in variance to be partitioned, and thus reduced power. Rather than adopt a treatment-control paradigm, the most parsimonious manner with which to assess the effect of reach scale habitat restoration actions is through a before-after (or one of its variants) time-series analysis. By comparing the same reach before and after treatment the issue spatial variance is side-stepped, and the ability to detect effects requires far fewer replicates. However, requiring pre-treatment data, often 3-5 years worth, is not compatible with adding effectiveness monitoring to projects after-the-fact.

3. Monitoring the physical and biological habitat effects of reach scale restoration actions cannot be used to assess the population level effects of the projects, either individually or collectively.

--The response variables from before-after or treatment-control monitoring of reach-scale habitat restoration actions will be the physical or biological habitat condition affected by the restoration action, or in rare cases, an indicator of a biological process that is indirectly affected by the habitat action through the action's effect on habitat condition. As such, reach-scale actions will not be assessed with fish population process based response metrics, and thus not in the currency of the assessment required of the FCRPS PA and BO. Furthermore, regardless if the response metric is indirectly or directly related to biological processes, it will only be on the spatial scale of the action, i.e., a reach. The assessment required of the FCRPS PA and BO is the effect of off-site mitigation actions on population processes at the scale of an entire population or major fraction thereof. Therefore, monitoring individual or collections of reach-scale projects at the scale of the projects alone cannot be used to assess off-site mitigation actions due to a mismatch in the currency and scale of these assessments and that required for the FCRPS PA and BO.

Therefore, to generate a programmatic assessment of the FCRPS PA an approach that is more than just the aggregate of project-scale effectiveness monitoring is required. Directly monitoring the population-level benefit of habitat restoration actions is possible, but difficult for a number of reasons, primarily due to the large scale presented by the "population" requirement, and the resulting effect size necessary to detect biological process changes at this scale. The goal will be to develop a transparent model that can be applied across different landscapes and populations, and provides reasonably accurate results. Such a model should allow researchers to examine the separate and combined effects of habitat and hatchery actions.

# Attachment 3

# The Pilot Study Approach

# Integrated Status and Effectiveness Monitoring Program

The Integrated Status and Effectiveness Monitoring Program (ISEMP – BPA project #2003-0017) has been created as a cost effective means of developing protocols and new technologies, novel indicators, sample designs, analytical, data management and communication tools and skills, and restoration experiments that support the development of a region-wide Research, Monitoring and Evaluation (RME) program to assess the status of anadromous salmonid populations, their tributary habitat and the effectiveness of restoration and management actions.

The most straightforward approach to developing a regional-scale monitoring and evaluation program would be to increase standardization among status and trend monitoring programs. However, the diversity of species and their habitat, as well as the overwhelming uncertainty surrounding indicators, metrics, and data interpretation methods, requires the testing of multiple approaches in order to develop the best guidance on strategies for standardizing regional RME. As such, ISEMP is developing a broad template that may differ in the details among subbasins, but one that will ultimately lead to the formation of a unified RME process for the management of anadromous salmonid populations and habitat across the Columbia River Basin.

ISEMP has been initiated in three pilot subbasins, the Wenatchee/Entiat, John Day, and Salmon. To balance replicating experimental approaches with the goal of developing monitoring and evaluation tools that apply as broadly as possible across the Pacific Northwest, these subbasins were chosen as representative of a wide range of potential challenges and conditions, e.g., differing fish species composition and life histories, ecoregions, institutional settings, and existing data.

ISEMP has constructed a framework that builds on current status and trend monitoring infrastructures in these pilot subbasins, but challenges current programs by testing alternative monitoring approaches. In addition, the ISEMP is:

1) Collecting information over a hierarchy of spatial scales, allowing for a greater flexibility of data aggregation for multi-scale recovery planning assessments, and
2) Designing methods that:
    a) Identify factors limiting fish production in watersheds;
    b) Determine restoration actions to address these problems;
    c) Implement actions as a large-scale experiment (e.g. Before After Control Impact, or BACI design), and
    d) Implement intensive monitoring and research to evaluate the actions' success.

The intent of the ISEMP project is to design monitoring programs that can efficiently collect information to address multiple management objectives over a broad range of scales. This includes:

• Evaluating the status of anadromous salmonids and their habitat;

- Identifying opportunities to restore habitat function and fish performance, and
- Evaluating the benefits of the actions to the fish populations across the Columbia River Basin.

The multi-scale nature of this goal requires the standardization of protocols and sampling designs that are statistically valid and powerful -- properties that are currently inconsistent across the multiple monitoring programs in the region. Other aspects of the program will also aid in the ability to extrapolate information beyond the study area, such as research to elucidate mechanistic relationships between habitat condition and population processes, and a classification of watersheds throughout the Columbia River Basin. In addition, ISEMP is working actively to develop analytical and data management approaches that incorporate existing data such that irreplaceable historical time series can be captured and utilized.

Obviously, the scale of the problem is immense and ISEMP does not claim to be the only program working towards this goal. As such, ISEMP relies heavily on the basin's current monitoring infrastructure to test and develop monitoring strategies, while acting as a coordinating body and providing support for key elements such as data management and technical analyses. ISEMP also ensures that monitoring programs can address large-scale management objectives (resulting largely from the ESA) through these local efforts. While ISEMP maintains a regional focus it also returns the necessary information to aid in management at the smaller spatial scales (individual projects) where manipulations (e.g., habitat restoration actions) actually occur.

A major difference between ISEMP and other monitoring design efforts is the integration of ISEMP with current sub-basin monitoring programs. We are relying on the current monitoring infrastructure to test and develop monitoring strategies, while acting as a coordinating body and providing support for key elements such as data management and technical analyses. The ISEMP also ensures that monitoring programs can address large-scale management objectives (resulting largely from the ESA) through these local efforts. While ISEMP maintains a regional focus it also returns the necessary information to aid in management at the smaller spatial scales (individual projects) where manipulations (e.g., habitat restoration actions) actually occur.

Therefore, explicit coordination with funding agencies is critical to ensure they understand that new programs must often address the information needs of existing projects in kind with their own. Explicit up-front participation of funding agencies in project coordination may also ease budget transitions and improve efficiency as existing and newly implemented activities are merged.

Standardizing protocols is another way ISEMP coordination has helped ensure that all available data are optimally utilized. For example, ISEMP developed interim protocols for the capture, handling, and tagging of wild salmonids in the Upper Columbia River Basin for projects that use PIT tags. The ISEMP collaborative process enabled information sharing among local field staff and outside experts. The initial success of this effort is reflected by the use of these protocols by all five state, federal, and tribal agencies engaged in this work in the Wenatchee/Entiat sub-basin and by the adoption of these protocols in other near-by sub-basins. Other products developed to meet similar objectives include sub-basin-scale monitoring strategies, a habitat field-survey manual, data entry templates, and a data management system. In short, this collaborative process provides a forum for an exchange of information that otherwise may not occur.

The ISEMP project has also been applying ecological principles to develop relevant indicators and conducting research to test if these relationships are realized. For example, macroinvertebrate assessments in monitoring programs throughout the Columbia River Basin use benthic species composition to create indicators of water quality. These indices, however, do not provide information on the quantity or quality of food available for drift feeding salmonids. In the ISMEP invertebrate productivity monitoring study, we are comparing estimates of terrestrial and aquatic drift and benthic invertebrate biomass to estimates of juvenile anadromous and resident redband trout (O*ncorhynchus mykiss gairdneri*) growth and density across multiple reaches and watersheds differing in temperature and habitat characteristics. From this study, we expect to determine the most relevant invertebrate metric (e.g. total invertebrate biomass) to fish performance.

It is important to develop a quantitative understanding of the strengths, weaknesses and relatedness of different protocols and their resulting metrics. Quality assessments and control on the accuracy and precision of a protocol should be a standard component of monitoring programs that include the evaluation of variance associated with observers, sites, and time. Side-by-side comparison of the accuracy, precision, and cost of implementation of multiple protocols establishes the basis for deciding the most reasonable protocol to adopt or whether to create "crosswalks" to convert values collected from one protocol to values collected from another. In this vein, ISEMP is conducting assessments of protocols for the development of physical and biological habitat condition metrics, and juvenile salmonid density and population estimation.

In addition to focusing on protocols or response designs, ISEMP is explicitly testing key aspects of sampling designs. The ability to extrapolate a collection of samples to provide an accurate assessment at the appropriate scale is dependent on the sampling design. The sampling design describes where, when, and how much to sample. The design is not only dependent on the protocols used to collect the information but on how the information will be used. In the John Day Basin, status and trend monitoring for juvenile and adult steelhead and Chinook populations and their habitat are conducted by ODFW based on a monitoring program that has been implemented in Oregon's coastal watersheds. A sampling program similar in design and effort to the John Day Basin project is being implemented in the Wenatchee sub-basin; however, the Wenatchee sub-basin is about 1/8 the size of the John Day basin, therefore the density of sample sites is effectively much higher. Thus, ISEMP can compare the influence of an increased density of sample sites on the precision of summary metrics. Analysis of variance structures will be evaluated as information becomes available to describe the power of the different sampling designs. In addition, subsampling routines of the data will be used to evaluate whether current designs are too intensive and thus wasteful for addressing relevant management objectives.

The ISEMP is initiating a test of an entirely different habitat and population status and trend project in the South Fork Salmon River (SFSR) watershed. This monitoring program will test a different set of protocols and sample designs in a "common garden" with existing programs to determine whether a single sampling design can return the information needed for multiple species/life histories, and whether relationships can be constructed to enable programs to employ alternative sampling methods without losing the time series of information that has been generated by existing infrastructure/sampling designs. This program also highlights the idea that the elements discussed thus far will not be evaluated in isolation but rather as an integrated approach to designing a monitoring program.

Large-scale experiments are arguably the most direct method available for predicting a population or environmental response to management. These experiments have contributed greatly to our understanding of ecological processes within watersheds, and results from many of these studies have led to changes in management strategies. However, generalization beyond a single system requires knowledge of mechanistic interactions or multiple ecosystem studies. To build on this tradition, Intensively Monitored Watershed studies to evaluate population level responses to large-scale restoration efforts have been initiated throughout the region. The ISEMP has proposed or is involved in IMWs in each of the pilot projects to evaluate large-scale restoration actions in an experimental framework approach.

Decreased habitat complexity has been implicated as the primary factor that limits freshwater productivity of ESA listed bull trout, spring Chinook salmon, and steelhead in the Entiat River basin. Approximately 60 artificial structures will be placed in a 16-mile section of the Entiat, which are expected to increase habitat complexity by encouraging pool scour and other geomorphic changes. In addition, six relict side-channels will be reconnected to the mainstem. The benefit of these restoration actions will be evaluated under the ISEMP Entiat IMW study.

An assessment of Bridge Creek (John Day River, OR) and several other interior Columbia River basin watersheds suggests that channel incision is a widespread problem for fish populations. Channel incision results in the lowering of floodplain water tables, the loss of off-channel habitat and riparian forest and a general simplification of stream habitat. In order to restore the aggradation, or stream-bed rebuilding, processes, ISEMP has initiated a large-scale restoration project in Bridge Creek through the application of two types of restoration structures that mimic strong, long-lasting beaver dams. Implemented actions should restore floodplain processes that will result in increased baseflow, lower summer temperatures, decreased sediment loads and greater habitat complexity such as more off-channel habitat, more riparian vegetation, and more frequent and deeper pools.

An IMW has also been designed for the Lemhi River, a tributary to the upper mainstem of the Salmon River. In the Lemhi River, habitat modifications and irrigation withdrawals have hydraulically isolated 28 of the 31 tributaries from the mainstem. A number of habitat restoration actions are intended to provide access to historical spawning and rearing habitat and increase habitat quality: (1) removing or reducing upstream and downstream migration barriers (e.g., pushup dams); (2) increasing tributary and mainstem flow; (3) maintaining or enhancing riparian conditions; (4) increasing the abundance and quality of off-channel habitat; and (5) increasing pool frequency and quality to improve productivity and over-winter survival. Ongoing and proposed habitat actions are aggressive and anticipated to result in measurable biological responses, both in terms of physical habitat attributes (e.g., quality and quantity of accessible habitat) and fish vital rates (survival/productivity, distribution, and abundance) both at the scale of individual reaches and at the scale of the watershed.

ISEMP's primary objective is to aid in the design of efficient and comprehensive monitoring programs to address multiple management objects, but it relies on current monitoring infrastructure for the implementation of monitoring. The ISEMP is also aiding in the development and application of tools to evaluate the diverse, extensive, and hierarchical nature of data collected as part of the pilot projects.

Analytical needs include the assessment of the utility of the different variables and indicators, which is related to the identification of potential causal mechanisms. Regression and multiple regression approaches will be common tools to evaluate whether predictor variables can explain the variation observed in the response variables, and can at least generate hypotheses about these relationships.

The precision and accuracy of different protocols, and the efficiency of sampling designs will have to be evaluated. Random effects analysis of variance models are the appropriate statistical tool to partition the spatial and temporal environmental heterogeneity, observation and measurement error and will be used to compare protocols and assess and refine sampling designs. Power analyses and sample size calculations will also be used to complement these evaluations.

The development of limiting factor analyses and the ability to address management questions are also analytical requirements of ISEMP. Reference and managed systems can be compared using ANOVA and ANCOVA approaches, and Partial Mantel tests can be used to identify a potentially important set of environmental relationships at multiple spatial scales from a large set of variables while accounting for spatial autocorrelations, while hierarchical models and structural equation modeling show promise in testing hypotheses about multiple factors regulating fish performance metrics using spatially explicit data.

The ISEMP is also developing classification tools to apply lessons learned from small-scale efforts to broader scale problems. The ISEMP has classified the watersheds of the Columbia River basin based on their potential to support anadromous salmonids, represented by a multidimensional numerical score for each watershed ($6^{th}$ field hydrologic unit code or HUC) based on reducing multiple spatial data layers. Generating the watershed scale descriptors requires the compilation of existing spatial data layers to generate consistent and complete coverages of biophysical conditions.

Developing a regional monitoring and evaluation program must overcome significant data organization and management challenges in order to meet program objectives. Regional projects produce an enormous volume of data from a plethora of collaborates, sites, and years. For example, in 2004, ISEMP data collection in the Wenatchee sub-basin produced nearly 250,000 unique data records. This sheer volume of data results in issues of storage capacity, retrieval, and distribution. Data collected by disparate collaborators is often stored in inconsistent formats and typically do not follow consistent rules of quality assurance, making automated processing nearly impossible. Most importantly, metadata about who, when, and how data were collected are not stored directly with data and is often lost or misplaced. In order to facilitate data quality assurance and transfer to regional databases, the ISEMP data management strategy is based on the integration of both localized and centralized data management efforts. A central database provides the storage capacity, metadata tracking, and data processing functionality to meet the needs of the regional monitoring and evaluation program. Unlike most centralized database programs, ISEMP also provides data management tools and guidance to encourage best data management practices within local agencies. Data management tools and guidance help ensure that newly collected data and historic data are structured in a format consistent with regional databases, that metadata is directly linked to raw data, and that a minimum level of data quality is assured at the time of data entry.

# Estuary and Ocean Research, Monitoring and Evaluation Proposed Action

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## Introduction

The estuary/ocean RME material here draws on the "*Plan for Research, Monitoring and Evaluation of Salmon in the Columbia River Estuary*" (Estuary/Ocean RME Subgroup 2004) and the "*Research, Monitoring and Evaluation – Conceptual Framework Outline*" (Sovereign Collaboration Group 2006). For the purposes of this document, the estuary/ocean is defined as the tidally-influenced portion of the river and its tributaries from Bonneville Dam to and including the plume and nearshore ocean; lower Columbia River tributary watersheds above tidal influence are not part of the study area.

## Management Questions

The following are the primary management questions that have emerged with respect to Estuary Habitat actions. The RM&E actions described in this section are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions. For the purposes of this document, the estuary/ocean is defined as the tidally-influenced portion of the river and its tributaries from Bonneville Dam to and including the plume and nearshore ocean; lower Columbia River tributary watersheds above tidal influence are not part of the study area.

- Are aquatic, riparian, and upland estuary habitat actions achieving the expected biological and environmental performance targets?

  This management question concerns primarily status and trends monitoring, in combination with action effectiveness research. Status monitoring is the "measurement of environmental characteristics over an extended period of time to

determine status or trends in some aspect of environmental quality" (from Suter 1993, cited in Noon 2003). Status monitoring can describe differences in values of given monitored indicators among locations at a given moment in time (snap-shot) or changes in their values across time at a given location (trend).

- Are the offsite habitat actions in the estuary improving juvenile salmonid performance and which actions are most effective at addressing the limiting factors preventing achievement of habitat, fish, or wildlife performance objectives?

  This management question concerns action effectiveness evaluation. Action effectiveness evaluation determines the biological and ecological effects of management actions relative to project and program objectives. The conclusions generated from action effectiveness evaluation will inform decision making in the adaptive management process for the Action Agencies' estuary restoration effort as a whole.

- What are the limiting factors or threats in the estuary/ocean preventing the achievement of desired habitat or fish performance objectives?

  This management question concerns critical uncertainties research. The resolution of uncertainties in the existing estuary/ocean knowledge base is required for implementation of appropriate management actions as well as associated status and trend monitoring and action effectiveness evaluation. "Uncertainties" are those pieces of information currently unavailable that managers require for informed, effective decision making. Critical uncertainties that pertain to the estuary but are rooted in the hydrosystem, e.g., delayed mortality, are addressed under Hydrosystem RME and are not included here.

## Performance Measures

Performance measures for the Columbia River estuary include reach survival, life history diversity, growth rates, and predation rates of juvenile salmonids and the bathymetry, topography, connectivity, and hydrology of estuary habitats. Survival benefits for actions implemented in the periods FY07-09 and FY10-17 for estuary habitat actions have been estimated for stream and ocean-type life histories and used within the biological assessment based on methods discussed in the Remand Collaboration process. These estimated benefits provide the long term biological performance targets.

Performance standards have also been set for annual tracking of project implementation projected for the periods FY07-09 and for FY10-17 used to estimate the long term survival benefits. RM&E will be used to confirm and improve our understanding of the relationships between different estuary habitat actions, the environment and the survival and productivity performance measures. As this information is developed and relationships and models are updated, the AA will re-confirm the modeling estimates of expected survival improvements associated with actions. More specific information on performance standards, targets and contingencies is provided in the Accounting, Adaptive Management and Contingencies section for the PA.

## Estuary and Ocean RM&E Actions

**Monitor and Evaluate Fish Performance in the Estuary and Plume:**

The Action Agencies will biological responses and/or environmental attributes, and report in the following areas:

- *Monitor and evaluate smolt survival and/or fitness in select reaches from Bonneville Dam through the estuary.*

  Survival is a fundamental performance measure. Survival rates will be estimated using tagging techniques for juveniles of selected species and life history types for the reach from Bonneville Dam to the CR mouth, and also for selected areas of the estuary.

- *Develop an index and monitor and evaluate life history diversity of salmonid populations at representative locations in the estuary.*

  An index for life history diversity is needed to monitor trends in this important indicator of salmon performance. An understanding of trends in life history diversity is important to assessing the performance of restoration projects.

- *Monitor and evaluate juvenile salmonid growth rates and prey resources at representative locations in the estuary and plume.*

  Growth rate is calculated as the change in length or weight of the sampled juvenile salmon population per unit time. It is a direct indicator of ecological benefits from estuarine habitats when coupled with monitoring of prey resources.

- *Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.*

  Predation on juvenile salmonids is a concern throughout the Columbia basin, as it is in the estuary and plume. Monitoring predators and their foraging rates will help determine the extent of this limiting factor on salmonid performance.

**Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions:**
The Action Agencies will monitor and evaluate selected ecological attributes of the estuary. The proposed actions include:

- *Map bathymetry and topography of the Estuary as needed for RM&E.*

  Bathymetry is a collection of depth points that represent the gradients of elevation and depth change along a surface. Topography measures of the height of a point on the surface of the sediment or soil of a location, expressed relative to a datum point. These data are essential to quantify and characterize estuary habitats for salmonids.

- *Establish a hierarchical habitat classification system based on hydro-geomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.*

Maps generated from surveys using aerial photos and photo points and completing then applying the hierarchical classification currently in development will allow the Action Agencies to monitor trends in estuary habitats beneficial to juvenile salmonids.

- *Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.*

  Habitat connectivity is a landscape-level indicator that shows the linkages between different habitat types in the ecosystem. This action would include an inventory of dikes, levees, tidegates, culverts, which restrict access by salmon to wetland habitats. The habitat connectivity index will provide a way to track habitat actions, although such an index remains to be developed. This action is needed because of the importance of habitat connectivity to the ecology of juvenile salmonids in the estuary.

- *Tabulate the amount of absolute acreage by habitat type that is restored or protected every year.*

  This is straightforward, routine tracking of habitat restoration and protection actions, organized by habitat type. This action requires knowledge from the hierarchical habitat classification system.

- *Evaluate migration through and use of various shallow water habitats from Bonneville Dam to the mouth towards understanding specific habitat use and relative importance to juvenile salmonids .*

  Travel times indicate the amount of time juvenile salmonids spend in the estuary. Migration pathways characterize the corridors and habitats where juvenile salmonids are predominately found migrating through the system.

- *Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, substrate characteristics, dissolved oxygen, temperature, and conductivity, at representative locations in the estuary as established through RM&E.*

  Habitat conditions reflect the quality of ecological support for juvenile salmonids. Since the Action Agencies desire to conserve and restore habitats that benefit juvenile salmonid performance, it is prudent to monitor the status and trends in the quality and quantity of these habitats.

- *Monitor and report on indices of productivity in representative locations in the estuary and ocean.*

  Productivity indices, such as primary and secondary production rates, reveal the capability of ecosystems to support salmonids.

**Monitor and Evaluate Habitat Actions in the Estuary:**
The Action Agencies will monitor and evaluate the effects of a representative set of habitat projects in the estuary. The proposed actions include:

- *Develop a limited number of reference sites for typical habitats, e.g., tidal swamp, marsh, island, and tributary delta, to use in action effectiveness evaluations.*

  A network of reference sites representing tidal marshes, tidal swamps, and other estuary habitats and having relatively undisturbed ecosystem structures and processes is required for action effectiveness monitoring of restoration projects. These sites can also serve as status and trend monitoring locations.

- *Evaluate the effects of selected individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives.*

  This action consists of monitoring at the site or project scale. Trends in core monitored indicators at restoration sites and a network of corresponding reference and status monitoring sites are analyzed to meet this objective.

- *Develop and implement a methodology to estimate the cumulative effects of habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem controlling factors, structures, and processes affecting salmon habitats and performance.*

  This action consists of research and monitoring at landscape, watershed, and site/project scales. The validation objective is to answer a question: "what was the cumulative effect of all habitat conservation and restoration efforts in the estuary relative to the program goal?" The answer to this question is critical to objectively determining whether habitat restoration actions in the estuary are positively affecting salmon.

**Investigate Estuary/Ocean Critical Uncertainties:**

The Action Agencies will fund selected research directed at resolving critical uncertainties that are pivotal in estuary mitigation and understanding ocean effects. These proposed actions include:

- *Continue work to define the ecological importance of the tidal freshwater, estuary, plume and nearshore ocean environments to the viability and recovery of listed salmonid populations in the Columbia Basin.*

  This is a major uncertainty, the resolution of which will determine the importance of estuary/ocean actions in the overall recovery effort for listed salmonids. This action includes studies to determine 1) the linkage between habitat conditions and growth and survival of juvenile salmonid fishes in the estuary and ocean, and 2) which ecosystem controlling factors, structures, and processes of the estuary and ocean are limiting for the salmon ESUs.

- *Continue work to define the causal mechanisms and migration characteristics affecting survival of juvenile salmon during their first weeks in the ocean.*

  The research need is to collect concurrent environmental and juvenile salmonid data during the first weeks in the ocean and correlate these data with adult salmonid returns.

- *Investigate the importance of early life history of salmon populations in tidal freshwater of the lower Columbia River.*

  Shallow water habitats in the tidal freshwater reach of the lower Columbia River and estuary are hypothesized to be important to the growth and survival of ocean-type salmon, such as Snake River fall Chinook salmon, but scientific knowledge specifically addressing this hypothesis is sparse and current monitoring efforts are fragmented.

- *Continue development of a hydrodynamic numerical model for the estuary and plume to support critical uncertainties investigations.*

  This action will entail hydrodynamic modeling to examine water velocity regimes and water surface elevations in order to understand the effects of the hydrosystem on habitat and salmonid performance. This information may provide the basis for management actions to aid recovery.

**Coordinate RME Activities:**
The Action Agencies shall coordinate estuary/ocean RM&E activities with other federal, state and tribal agencies. Proposed actions include:

- *Organizing and supporting the COE Anadromous Fish Evaluation Program.*
- *Support and participate in the NPCC Fish and Wildlife Program planning efforts.*
- *Support the standardization and coordination of tagging and monitoring efforts through participation and leadership in the Pacific Northwest Aquatic Monitoring Partnership.*
- *Coordinate RME through the Estuary/Ocean RME Subgroup.*

**Manage and Disseminate Data:**
The Action Agencies will ensure that the information obtained under the auspices of the estuary/ocean RM&E Program is archived in an appropriate data management system. Proposed actions include:

- *Work with regional agencies and forums such as the Northwest Environmental Data-network (NED) to establish an integrated and networked regional database system.*
- *Contribute funding for data system components that support the information management needs of Estuary/Ocean RM&E.*

## Estuary and Ocean RM&E Projects

See Table 3, Appendix 1 for specific projects that have been currently identified for implementation in the FY07-FY09 period to meet the Proposed Actions for Estuary and Ocean RM&E.

*This is not a final federal agency product. Rather, it is a pre-decisional document prepared by the Action Agencies that reflects present understandings of currently available information and analyses, and of the progression of discussions with the sovereigns in the collaborative process. Revisions and refinements are to be expected based on further discussions with the sovereigns over new and modified proposed federal actions upon which the action agencies will ultimately consult. Finally, the information in this product does not constitute an analysis of whether the identified measures would or would not jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Furthermore, this document does not in any way interpret or apply the regulatory definitions of the statutory phrases "jeopardize the continued existence of" and "destruction or adverse modification."*

# Hatchery Research, Monitoring and Evaluation
# Proposed Action

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## Introduction

This appendix to the RM&E Proposed Action (PA) provides additional details regarding monitoring and evaluation that will be implemented to answer key management questions regarding the achievement of hatchery performance standards/targets, the effectiveness of hatchery actions, and critical uncertainties regarding the relationships of hatcheries to the viability of ESA listed populations. Performance metrics, monitoring approaches, and proposed actions needed to answer these management questions are identified, along with the associated proposed actions needed for tracking implementation of hatchery projects, coordination of these research and monitoring actions with regional agencies, and management of hatchery RM&E data.

## Management Questions

The following are the primary management questions with respect to hatchery actions. Hatchery RM&E actions are focused on providing information needed to answer these questions to support ongoing and adaptive management decisions.

(1) Are hatchery improvement programs and actions achieving the expected biological performance targets?
(2) What is the proportion and origin of hatchery fish within naturally spawning salmon and steelhead populations?

(3) Can hatchery reforms reduce the deleterious effects of artificial production on listed populations, thereby contributing to a reduction in extinction risk for affected natural populations?
(4) Can properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations?
(5) What is the reproductive success of hatchery fish spawning in the wild relative to the reproductive success of wild fish?

Answers to these questions will require a combination of status monitoring, action effectiveness research, critical uncertainty research, and project implementation and compliance monitoring. Information from monitoring and research will inform assessments of fish performance relative to annual performance standards and longer term targets and guide adaptive management decisions.

Existing BPA-funded hatchery RM&E (Table 5, Appendix 1) identified for implementation in the FY07-FY09 period is anticipated to partially serve the information burden required to address many of the questions described in the previous paragraph. Further review and recommendations for modification of ongoing RM&E work as well as identification of any additional, essential RM&E projects are planned (see the "*Next Steps*" section in this document). The process outlined in the "*Next Steps*" section includes a means to prioritize existing and proposed RME based on its value towards satisfying the research requirements that accompany the Hatchery PA.

## Performance Measures

Although ongoing hatchery RME has targeted many of the research needs described in the Hatchery PA, existing information remains insufficient to quantitatively estimate the effects of many of the actions proposed in the Hatchery PA. Thus, the expected benefits of the proposed actions were qualitatively assigned as high, medium, or low. These benefits represent our performance targets for adaptive management. Hatchery action effectiveness research will be used to help confirm and update our qualitative expectations of these benefits as new information becomes available.

These benefits (performance targets) are relative to the following objectives of the hatchery actions:

- Safety-net programs reduce extinction risk for target populations in Snake River sockeye, Snake River spring/summer Chinook, Mid-Columbia River steelhead, Lower Columbia River steelhead, and Columbia River chum salmon ESUs.
- Conservation hatchery programs increase abundance of target populations in Snake River spring/summer Chinook, Snake River fall Chinook, and Upper Columbia steelhead ESUs/DPSs, thereby reducing the time to recovery.
- High-priority hatchery reform actions, i.e., those needed to address hatchery programs that are considered major limiting factors by NOAA, result in improved abundance, productivity, diversity, and/or spatial structure of target populations.

- Future implementation of additional hatchery reforms identified through Columbia River Hatchery Scientific Review Group's hatchery review process, combined with use of Best Management Practices at FCRPS hatchery facilities, improve abundance, productivity, diversity, and/or spatial structure of target populations, depending on the nature of the reform.

In addition to these qualitatively rated benefits (performance targets) associated with the objectives identified above, a more quantitative assessment approach has been applied within the BA for the benefits associated with improved hatchery management practices. This assessment associates changes in hatchery management practices that have been implemented to date, to a change from historic-to-current relative reproductive success (RRS) of hatchery origin fish spawning under natural conditions. This change in reproductive success of hatchery fish and the number of hatchery fish spawning over time has been used to estimate a survival improvement for supplemented populations. Ongoing and proposed research on the reproductive success of hatchery fish spawning in the wild will be used to help confirm the estimated current RRS used in the historic-to-current improvement in RRS and update modeled population effects where needed.

Programmatic performance standards will be developed for Best Management Practices that are being set for various hatcheries based on ongoing regional program reviews.

## Best Management Practices

The Hatchery Proposed Action (PA) identifies the implementation of numerous "best management practices" (BMPs) as a means to limit risks and increase the potential benefits of hatchery operations. In some cases the BMPs are required to ensure compliance with the provisions of the Endangered Species Act (ESA; e.g., broodstock transitions). The BMPs can be categorized based on their anticipated impact(s):

1. Broodstock transition – replace production derived from non-local or composite broodstock with local-origin fish.
2. Follow the Hatchery Scientific Review Group's recommended guidelines for Proportion of Natural Influence (PNI) [1] – requires the ratio of hatchery to natural adults used for broodstock and released for natural production to conform to specific standards to reduce risks to the natural population.
3. Improve broodstock collection practices – change broodstock collection practices to better represent natural genetic and life history diversity in the broodstock.
4. Terminate artificial propagation – end programs that are believed to incur high risk and have a low probability of providing benefits.
5. Decrease production – limit production to achieve a better balance of hatchery and natural influence.

[1] PNI (Proportion of Natural Influence) = pNOB/(pHOS + pNOB), where pNOB is the proportion of natural-origin fish included in the hatchery broodstock and pHOS is the proportion of hatchery-origin fish in the natural spawning escapement.

6. Link hatchery production goals to biological controls – match production and the escapement of hatchery origin adults to carrying capacity and or recovery targets.
7. Implement reintroduction – utilize hatchery production to stimulate natural production in areas formerly occupied by now-extinct populations.
8. Implement supplementation – implement artificial propagation programs that utilize broodstock composed of local natural-origin adults to increase abundance, decrease extinction risk, maintain genetic and life-history diversity etc.
9. Improve facilities – e.g., to minimize impacts from water withdrawals, decrease impedance at broodstock collection structures, improve rearing conditions etc.
10. Implement acclimation – build facilities to hold juveniles in targeted habitat for a period prior to release; often used to improve homing.

## Hatchery RM&E Proposed Actions

*Monitor Hatchery Effectiveness*

The Action Agencies will fund selected ongoing and proposed monitoring and evaluation of the effectiveness of proposed hatchery actions. The Action Agencies propose two primary actions to address the effectiveness of hatchery actions:

- *Determine the effect that safety-net and conservation hatchery programs have on the viability and recovery of the targeted populations of salmon and steelhead.*
- *Determine the effect that implemented hatchery reform actions have on the recovery of targeted salmon and steelhead populations.*

The evaluation of hatchery projects will be coordinated with the Tributary Habitat monitoring and evaluation program.

*Investigate Hatchery Critical Uncertainties*

The Action Agencies will fund selected ongoing and proposed research directed at resolving artificial propagation critical uncertainties:

- *Estimate the relative reproductive success of hatchery-origin salmon and steelhead compared to reproductive success of their natural-origin counterparts.*
- *Determine if hatchery reforms reduce the deleterious effects of artificial production on listed populations, thereby contributing to a reduction of extinction risk for the affected natural populations.*
- *Determine if properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations.*

The AA will place a priority on hatchery critical uncertainties research in areas where answers to hatchery management questions are most critical to the success of the PA. Answers to hatchery critical uncertainties are most critical for Upper Columbia River steelhead, Snake River Spring/Summer Chinook, Snake River B-run Steelhead, and Snake Fall Chinook.

## RM&E Approach

The research needs of the Hatchery PA range from the identification of very specific information requirements, such as the effectiveness of improving specific hatchery facilities, to very general questions such as estimates of relative reproductive success. Given the range of research specificity identified in the Hatchery PA, we have taken the approach of identifying both:

- large-scale design alternatives that will satisfy all or part of the information needs of multiple questions and
- program-specific research that is more directly targeted at individual BMPs, uncertainties, or action effectiveness questions developed in the Hatchery PA.

Within each of the classes of actions included in the Hatchery PA, there exist at least two common questions, namely: 1) what is the distribution and abundance of hatchery origin adults relative to natural origin adults and 2) what is the reproductive success of hatchery origin adults spawning under natural conditions relative to their natural origin counterparts?

*Distribution and Abundance of Hatchery Origin Adults Relative to Natural Origin Adults*

Generally, the escapement of hatchery origin adults into targeted populations is routinely measured by RME accompanying conservation and safety-net hatchery programs. However, the destination of "strays" from conservation and safety-net programs as well as mitigation facilities is not currently well understood. These strays have the potential to confound actions by:

1. Altering mean productivity of recipient populations, potentially masking improvements in freshwater survival that are expected to accompany habitat actions.
2. Decreasing productivity of populations targeted by conservation or safety-net hatcheries.
3. Increasing the complexity of productivity estimates, owing to uncertainty regarding the fraction of escapement composed of stray adults and subsequent uncertainty about how to "count" hatchery origin adults in escapement estimates. This is particularly problematic for ESA evaluations of recovery and delisting criteria.

Currently, many artificial propagation programs evaluate the stray rate of their production groups using an existing network of coded wire tag (CWT) recovery locations. However, there are numerous shortcomings of this method, not the least of which is that recovery sites are non-randomly selected thus making extension of results to un-sampled locations impossible. The Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) has designed a Columbia River Basin scale approach for evaluating stray ratios (the fraction of a population composed of stray hatchery origin adults) of stream-type Chinook salmon using a stratified sampling approach to distribute effort. That design is being evaluated by the *Ad Hoc* Supplementation Workgroup (AHSWG[2]) and should be completed by early 2008. Implementation of that design, or a similar method, would enable managers to predict stray ratios for streams where estimates cannot be directly calculated. Likewise, the design enables an evaluation of which types of hatchery programs and which specific hatchery programs contribute

[2] The AHSWG is a voluntary group of hatchery researchers intended to satisfy a request by the ISAB and ISRP (2005) to convene an *ad hoc* group to evaluate the potential to use "Basinwide" designs to address several remaining critical uncertainties that accompany supplementation.

to straying; thus enabling an evaluation of hatchery practices that contribute to straying. The completion of similar designs for steelhead and ocean-type Chinook salmon are proposed for completion by the Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) in 2008.

*Relative Reproductive Success*

The need for a large-scale design to evaluate the reproductive success of hatchery origin adults relative to natural origin adults under natural conditions has been reiterated by multiple groups (e.g., ISAB/ISRP 2005). Generally, there are two related questions:

1. What is the relative reproductive success (RRS) of conservation or safety-net hatchery origin adults in their targeted populations? and
2. What is the impact of stray hatchery origin adults (from either supplementation or harvest augmentation programs) on the productivity of non-target populations?

Information relative to those two questions would enable habitat, conservation, and safety net hatchery monitoring projects to estimate the impacts of strays on freshwater productivity estimates; potentially enabling disentanglement of the often confounding influences of hatchery and habitat actions. Additionally, that information would enable the impacts of strays to be directly evaluated when calculating measures of productivity for the purposes of ESA listing decisions. Finally, addressing these two questions would provide some of the information necessary to address two of the primary uncertainties regarding the effectiveness of hatcheries – namely their potential benefits for targeted populations and the magnitude of the potential impact that hatchery might have on non-targeted populations (i.e., the "net" impact of hatcheries).

The CSMEP group has designed a Columbia River Basin scale approach for evaluating the RRS of hatchery origin stream-type Chinook adults in target and non-target populations using a stratified sampling approach to distribute effort. That design is being evaluated by the AHSWG and should be completed by early 2008. Importantly, the primary stratum for that design is PNI; thus enabling a direct evaluation of the influence of PNI on relative reproductive success. Additional designs to evaluate RRS for steelhead and ocean-type Chinook salmon are proposed for development in CSMEP in 2008.

*Combining Large-Scale and Program Specific Evaluations*

The large-scale designs described earlier are capable of providing representative estimates of stray rates/ratios of hatchery origin adults and their anticipated reproductive success in target and non-target populations. Those designs also enable evaluations of BMPs 2, 5 and 10 (implementation of PNI targets, balancing escapement of hatchery and natural origin adults, and use of acclimation to reduce stray ratios) and directly address at least part of the information requirements associated with uncertainties and effectiveness research required by the Hatchery PA. Generally, the application of the large-scale designs reduces the remaining RME burden to evaluating:

1. BMPs 1, 3, 4, 6, 7, 8, and 9.

2. Whether conservation and safety-net programs can decrease extinction risk and contribute to recovery.
3. Evaluating whether specific hatchery operations can increase benefits and reduce risks.

BMP 1 (broodstock transition) could be viewed simply as an ESA compliance issue. In short, non-local or composite broodstock is considered unacceptable for ESA purposes, so simply documenting the transition (implementation and compliance monitoring) may be all that is necessary. If effectiveness monitoring is desirable, one could conduct simple paired comparisons of the performance of the non-local or composite brood relative to the new local brood. In practice it is unlikely that most programs will undergo the transition instantaneously due to the logistics involved (e.g., there may not be an adequate number of local fish available for broodstock), thus it is likely that the existing brood and the new local brood would be used simultaneously for some period. Thus paired comparison should be possible and could be cost-effectively achieved for many performance measures by simply marking the release groups (composite or non-local versus local) differentially.

BMPs 3, 4, and 9 (collection of representative broodstock, program termination and facility improvements) represent specific actions recommended for specific programs. We assume that these recommendations are based on the results of existing RME given that some information would be required to determine that existing practices are problematic and to prescribe the BMPs to remedy the problem(s). We further assume that simply continuing the existing monitoring would therefore likely be sufficient to evaluate the effectiveness of implementing the BMPs.

BMP 6 (linking hatchery production to habitat capacity) provides the opportunity for a clear linkage between habitat action effectiveness and/or status and trend monitoring with hatchery action effectiveness. Designs to address this BMP are described in the following section on combining habitat and hatchery monitoring.

BMPs 7 and 8 (implementing reintroduction and supplementation programs) will likely require extensive monitoring. However, the two large-scale designs dramatically reduce the uncertainties research burden that would otherwise accompany the implementation of these BMPs.

*Next Steps*

The previous discussion summarizes how a combination of large-scale designs and site specific evaluations can be used to satisfy the RME requirements identified in the Hatchery PA. We now describe a proposed process to ensure that the information provided by existing hatchery RME is efficiently utilized, identify remaining information needs, and identifying how the existing suite of hatchery RME can be modified, if necessary, to at least partially satisfy the identified gaps in information.

Our approach consists of eight steps:

1. Translating the BMPs, uncertainties questions, and action effectiveness information needs described in the Hatchery PA to statistically tractable large-scale and project-specific designs.
2. Development of balanced stratified designs to address issues related to straying and RRS in a representative manner over a specified time interval.
3. Development of efficient designs to address project-specific information needs that are not satisfied by large-scale designs.
4. Identification of ongoing hatchery RME that provides information relevant to large-scale and program specific designs.
5. Identification of existing RME that is not necessary to satisfy information needs and evaluation of the necessity of those programs.
6. Identification of remaining information needs.
7. Recommendations for transition, modification, or elimination of current hatchery RM&E efforts coupled with development of a request for proposals to implement monitoring activities sufficient to meet the remaining information needs.
8. Development of standardized performance measures, associated analyses, and standardized reporting requirements to accompany existing and proposed research undertaken to provide the necessary information.

Components one through three will require significant collaboration between on-the-ground researchers, statisticians, and program managers through RM&E collaborative workgroup efforts. The hatchery RM&E effort will also require significant collaboration and coordination with the NPCC, the relevant hatchery operators, and fishery co-managers. Once the actions proposed in the Hatchery PA are described in a statistically tractable manner, a significant effort will be required to determine the degree to which existing hatchery RME can populate those designs (ISAB 2004). In short, we must determine which questions can be addressed given current RME and sufficient time. Secondly, researchers must evaluate information needs that cannot be sufficiently addressed given current RME, and devise an implementation plan to address those deficiencies. This evaluation could build upon the "gaps" analysis conducted for hatchery RME in 2003 (Smith 2003). Similarly, the workgroup should identify existing and proposed hatchery RME that is unnecessary to meet the information needs specified in the designs. Those RME elements deemed unnecessary to evaluate the impact of the Hatchery PA should then be scrutinized to determine if their termination would adversely impact the ability to make decisions with regard to other BiOp related elements (e.g., hydrosytem evaluations or the ability to assess the status and trends of populations) and/or would impact the ability to successfully operate the hatchery program. Elements that cannot be terminated should be appropriately categorized within the Fish and Wildlife program with regard to the monitoring activities that they support (e.g., hydrosystem evaluations, hatchery operations[3] etc.). Finally,

[3] For example, many supplementation programs employ risk-aversion methods that require a specified proportion of natural origin fish in broodstock and place limits on the proportion of escapement to natural production that consists of hatchery origin adults. Implementation of this management feature requires the ability to estimate hatchery ratios in escapement and relatively strict control on the number of hatchery origin adults allowed to spawn naturally. Typically the information required to implement this type of risk-aversion is funded through RME, but should more appropriately be considered part of hatchery operations.

reports describing progress towards meeting design objectives, evaluating sufficiency of the implemented program, and reporting the results when appropriate.

Although the implementation of the approach described above is challenging, there are numerous benefits. For example, under the *status quo*, every hatchery program must be accompanied by a relatively extensive RME plan. Under this proposed approach, a subset of hatcheries could be selected for research, and because the selection process utilizes a balanced stratified design, the results of that research could be applied to the remaining hatcheries which could then be accompanied by a significantly reduced RME burden. Thus, this enables a prioritization of hatchery RME activities on a regional scale and at the scale of individual programs. In short, hatchery programs could be grouped into strata, for example based on the ecoregion where they are located, species/life-history(ies) that they propagate, purpose (integrated versus isolated), etc. Each program would likely meet a number of status and trend, effectiveness, and uncertainties information needs. With an appropriate statistical design, it would be possible to select hatchery programs based on their existing RME programs, potential to meet additional information needs, and their ability to populate strata in order to meet the information needs of the designs.

## Integrating Habitat and Hatchery RME Efforts

The success of hatchery production hinges, among other factors, on the availability of high quality habitat of sufficient capacity to support either deliberate (i.e., in the case of supplementation, safety-net, or conservation programs) or unintended (in the case of mitigation or production hatcheries) increases in juvenile and adult abundance in freshwater spawning and rearing habitat. The success of habitat actions, measured as an improvement in freshwater productivity (e.g., smolts per redd or smolts per female), rests on the correct identification of habitat factors that limit productivity or survival, implementation of actions that modify physical attributes of the environment and the mechanistic translation of those actions to increased productivity or survival. Thus, the relationship between hatchery and habitat actions is clear. This relationship transfers in a more complex manner to the evaluation of the effectiveness of hatchery and habitat actions. Hatchery production adds to the complexity of evaluating habitat actions by at least two mechanisms:

- If hatchery production significantly exceeds habitat capacity prior to and following the implementation of a habitat action; even a habitat action that successfully increases habitat capacity or quality may have no detectable influence on freshwater productivity.
- If hatchery origin juveniles or adults decrease freshwater productivity (e.g., through the introduction of disease, predation, competition, or a decrease in reproductive success) a habitat action that might otherwise have improved freshwater productivity may have no detectable impact.

As detailed in prior sections, it is likely that some habitat and hatchery effectiveness evaluations will require contrasts between “treated” and “reference” streams. From an experimental design perspective, the relationship between hatchery and habitat actions is potentially problematic for the following reasons:

- Unless the distribution and magnitude of habitat actions is similar in treated and reference streams used for hatchery evaluations, comparisons of freshwater productivity between them will be confounded.
- Unless the distribution and magnitude of hatchery actions/impacts (e.g., stray ratios) is similar in treated and reference streams used for habitat evaluations, comparisons of freshwater productivity between them will be confounded.

Unfortunately the impacts of habitat and hatchery actions on freshwater productivity are not well quantified, and are in fact the subject of the RME proposed in this document. Thus we lack the information required to disentangle the impacts of one from the other. In this Chapter, we evaluate the potential for improving habitat and hatchery designs by considering them jointly. Two opportunities are considered:

1. Implementation of intensive monitoring in select locations to validate and evaluate the performance of model-based approaches that evaluate freshwater productivity as a function of habitat features, explicitly incorporating the impacts of hatcheries; and
2. Identification of opportunities to implement population and habitat status and trend monitoring to serve the reference requirements of both habitat and hatchery designs.

*Implementation of Intensive Monitoring to Validate and Evaluate Model-Based Designs*

In this section we provide three examples of proposed projects that combine elements of status and trend and effectiveness monitoring to jointly evaluate the effectiveness of habitat and hatchery actions. Although rare, the identification of opportunities such as those described below should be a high priority for evaluating the habitat and hatchery PAs.

Numerous model-based designs have been identified in Appendix 3, Tributary Habitat RM&E. An example of how those designs can be leveraged to simultaneously serve habitat and hatchery information needs is provided by the Integrated Status and Effectiveness Monitoring Project (ISEMP) population and habitat status and trend monitoring project proposed for implementation in the South Fork Salmon River (SFSR) of Idaho. The South Fork Salmon River contains both a safety-net artificial propagation program that supplements the spring/summer Chinook salmon population in Johnson Creek, and a large mitigation program that propagates spring/summer Chinook salmon to support fisheries targeting the population residing in the mainstem South Fork Salmon River. In addition, a third population of spring/summer Chinook salmon that is not targeted by hatchery actions resides in the Secesh River. Together the three populations form a single Major Population Group (MPG) of spring/summer Chinook salmon. A model, similar in nature to Shiraz, was developed to investigate life-stage specific mortality and abundance as a function of habitat quantity (capacity) and quality (survival). Given sufficient information, the model framework can explicitly incorporate survival and productivity functions for hatchery and natural origin adults and juveniles as well as crosses. The SFSR provides a somewhat unique opportunity to simultaneously address habitat, hatchery, and status and trend information requirements of the PA owing to the operation of two hatchery programs that represent a large range in hatchery management, and their proximity to a potential reference stream (the Secesh River).

Implementation of an RRS study in Johnson Creek would enable an evaluation of the reproductive fitness of adults produced by a safety-net hatchery with a mean PNI of 0.79 (Craig

Rabe, Nez Perce Tribe, Personal Communication, 27 February 2007) as well as the reproductive fitness of stray hatchery adults from the large mitigation facility (McCall Hatchery) located in the adjacent mainstem SFSR. From the perspective of habitat RME, implementation of this project would enable a direct evaluation of the impacts of hatchery origin adults on freshwater productivity in targeted and non-targeted populations and enable an evaluation of whether model-based approaches can remove the influence of hatcheries from evaluations of the effectiveness of habitat actions. From the perspective of hatchery RME, the implementation of the RRS study in Johnson Creek would enable an evaluation of the reproductive fitness of adults produced by a safety-net program and would enable an evaluation of the impacts of stray mitigation adults on productivity of a supplemented population.

The Upper Columbia provides an example of how model-based and design-based studies can be integrated to address both hatchery and habitat treatment effects. The Wenatchee basin contains both a supplementation/conservation hatchery program and a mitigation hatchery program. In addition, there are several habitat actions that will be implemented in the Wenatchee basin, most of which address primary limiting factors such as connectivity, off-channel and riparian habitat, and stream flows. The following RME activities presently occur within the Wenatchee basin:

- Status and trends of habitat and population characteristics (at the population scale) are monitored under ISEMP using a rigorous design-based approach.
- The effectiveness of the supplementation/conservation program is monitored at the population scale using a paired control-treatment design. Potential reference streams being evaluated by the Hatchery Evaluation Technical Team include the Naches River in the Yakima basin, the Secesh River in the Salmon, and Marsh and Lake creeks in the Salmon.
- Relative reproductive success of supplemented spring Chinook is being studied in the Wenatchee basin.
- Some of the habitat actions (e.g., off-channel habitat actions) are monitored for effectiveness at the reach scale.

The status/trend, effectiveness monitoring studies, and reproductive success studies are all integrated to provide maximum spatial coverage at the lowest cost. Finally, a Shiraz-type model is being developed by the NOAA Science Center for the Wenatchee basin. This model relies on data collected under the monitoring programs and will help tease apart the effects of hatchery and habitat actions on population metrics.

In summary, the identification of opportunities such as those provided by the SFSR and the Upper Columbia to coordinate habitat and hatchery RME could provide information that would not otherwise be produced by isolated implementation of research.

*Coordinated Identification of Reference Opportunities for Habitat and Hatchery RME*

In this section we provide two examples of proposed projects that utilize one or more reference streams to jointly evaluate the effectiveness of habitat and hatchery actions. Because of the cost-savings associated with the use of a reference location for both types of effectiveness monitoring, the identification of multipurpose references should be a high priority in both the habitat and hatchery PA appendices.

As described in the introduction, reference streams/populations will likely be required to satisfy both the habitat and hatchery RME requirements described in the PA. The identification of locations that serve as references for both habitat and hatchery evaluations would increase the efficiency of the monitoring program and would decrease the likelihood of implementing management actions that would confound treatment and reference comparisons. Again, the SFSR provides a good example of one such opportunity. The Secesh River (a tributary to the SFSR) is not affected by any current habitat actions, with the exception of grazing limitations, and likewise has never been directly supplemented. In fact, the Secesh River and its largest tributary (Lake Creek) are currently used as a reference stream by the Idaho Supplementation Studies project. Other potential reference streams for stream-type Chinook salmon include the Naches River in the Yakima basin and Marsh Creek in the Salmon basin. These streams are currently being evaluated by the Upper Columbia Hatchery Evaluation Technical Team as potential reference areas for the hatchery supplementation programs in the Upper Columbia basin. These streams could potentially serve as a reference system for habitat actions proposed for the East Fork SFSR and in the Upper-Columbia.

In short, the designation of streams such as Lake Creek as references for both hatchery and habitat actions could improve our ability to exclude management actions in those locations that otherwise might confound comparisons. Likewise, by using those locations as references for multiple studies the overall cost of monitoring would be reduced.

## Project Implementation and Compliance Monitoring

Hatchery projects will be monitored for implementation of planned deliverables and compliance to performance expectations. Implementation monitoring documents the type of hatchery action, its location, and whether the action was implemented properly and completely or complies with established standards. It does not require collection of biological or environmental data. The AA will use PNAMP standards where applicable for project tracking to support regional coordination of project implementation tracking and effectiveness monitoring designs.

Implementation and compliance monitoring will answer two primary questions: (1) were the actions implemented completely and according to expected schedules and (2) were the actions implemented correctly.

- *The Action Agencies will monitor the successful implementation of projects through standard procedures and requirements of contract oversight and management, and review of project deliverables and final reports.*
- *The Action Agencies will maintain BiOp databases to provide fish improvement and monitoring project and action level details for planning and reporting purposes. This approach will provide the most up-to-date information about the status of actions and projects being implemented.*
- *The Action Agencies will use the project level detail contained in the Action Agencies' BiOp databases to track results and assess our progress in meeting programmatic level performance targets. This performance tracking will be reported through annual progress reports and the 2012 and 2015 comprehensive reports.*

## RM&E Coordination and Data Management

The Action Agencies will coordinate RM&E activities with other federal, state and tribal agencies, and will ensure that the information obtained under the auspices of the FCRPS RM&E efforts is archived in appropriate data management systems. See the RM&E Coordination and Data Management section of the RM&E PA for specific actions. Much of the RM&E coordination and data management related to hatcheries will be carried out under the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), the Northwest Environmental Data-network and the pilot studies in the Upper Columbia, John Day and Upper Snake currently being implemented through the ISEMP project.