**Department of Energy**

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

ENVIRONMENT, FISH AND WILDLIFE

August 27, 2010

In reply refer to: KEWR-4

Mr. Tony Grover, Fish and Wildlife Division Director
Northwest Power & Conservation Council
851 S.W. Sixth Avenue, Suite 1100
Portland, OR 97204-1348

RE: CREST Habitat Restoration Project, project #2010-004-00

Dear Mr. Grover:

In response to Independent Scientific Review Panel (ISRP) review, Bonneville Power Administration (BPA) and the Columbia River Estuary Study Taskforce (CREST) are submitting additional information on CREST's Habitat Restoration Project, project #2010-004-00. This project supports implementation of the 2008 Federal Columbia River Power System Biological Opinion under the Reasonable and Prudent Alternative (RPA) 37, which is focused on improving juvenile and adult fish survival in the estuary habitat.

On July 26, the Council, BPA, ISRP and CREST participated in a conference call to discuss the ISRP comments and the intention of the project. As a result of the discussion, CREST and BPA are providing additional information about the project for ISRP, including an example of CREST's RM&E efforts and information on BPA's Estuary Program. Please find this additional information attached for ISRP review.

The ISRP has expressed concern on the programmatic approach BPA is taking with habitat projects. The concerns include decision/prioritization criteria, local technical evaluation protocols and clarification of the respective roles of the ISRP and local technical teams. To this end, BPA and Council staffs have agreed to work collaboratively with the ISRP in the near future to address programmatic habitat projects, but because of the timing of this proposal it will not benefit from that effort. To the extent practicable, we will incorporate elements of this future collaborative work effort in future programmatic habitat projects.

If you have questions about this information, please contact the project sponsor, Micah Russell at mrussell@columbiaestuary.org or at BPA, John Baugher the project manager at jrbaugher@bpa.gov or Marchelle Foster mmfoster@bpa.gov who is helping to coordinate ISRP responses.

Thank you for your assistance, we look forward to working closely with you and your staff as we implement BiOp projects.

Sincerely,

William C. Maslen
Director, Fish and Wildlife

Enclosures:
CREST Estuary Habitat Restoration Project Narrative
BPA Estuary Program Overview

cc:
Mr. Micah Russell, CREST (electronic mail)

CREST
Columbia River Estuary Study Taskforce
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CREST conducts habitat restoration effectiveness monitoring in the Columbia River Estuary (CRE), in both Oregon and Washington. For the past 10 years, CREST has housed a monitoring department with qualified and experienced biologists, ecologists, wetland specialists and technicians. CREST also maintains all the necessary boats and equipment, as well as a laboratory for processing fish prey utilization and availability samples. The monitoring department utilizes grants and contracts to monitor CREST-sponsored restoration projects, but is also frequently contracted to perform monitoring for other project sponsors and academic researchers. The majority of CREST's monitoring contracts center around juvenile salmonid use of restored habitats, primarily in tidal areas of the lower CRE. CREST conducts pre- and post-project monitoring to determine whether or not restoration projects are achieving defined ecological and fish benefit goals. Biological monitoring of water quality, fish community, fish prey utilization and availability, landscape level changes, and vegetation are implemented; locations and duration are subject to the availability of funding. Ultimately, this work informs improvements in future restoration project prioritization and design.

CREST was a co-author of *Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River Estuary* (Roegner et al, 2009), and continues to partner with and provide monitoring services for numerous organizations, including: Pacific Northwest National Laboratories (PNNL), NOAA, Columbia Land Trust, University of Washington, Lower Columbia River Estuary Partnership (LCREP), North Coast Land Conservancy, and the North Coast Watershed Association. Consistent well-developed monitoring protocols are a critical for cooperative long-term data collection and comparability. Field data collected by CREST is frequently utilized in partner presentations, reports, and publications. CREST data is also being utilized in efforts to evaluate the overall status of CRE restoration, including the Army Corps of Engineers / PNNL *Cumulative Effects* study and the LCREP *Meta-Analysis.*

CREST biologists and ecologists are experienced boat operators who have worked in a variety of habitats in the CRE and its tributaries. Monitoring staff also have experience with inserting PIT tags and operating PIT tag arrays; radio tag insertion and tracking; use of fyke, trap nets, and beach seines; collecting and analyzing invertebrate, gastric lavage, and genetic samples; and, data management and analysis.

The following documents a key project at which CREST has performed pre- and post-project monitoring. The Fort Clatsop *South Slough* project is one of four sites selected for long term effectiveness monitoring by LCREP/BPA because it is thought to be representative of habitat response in the tidal, brackish portion of the lower CRE.

**Case Study: Fort Clatsop South Slough Tidal Habitat Reconnection**

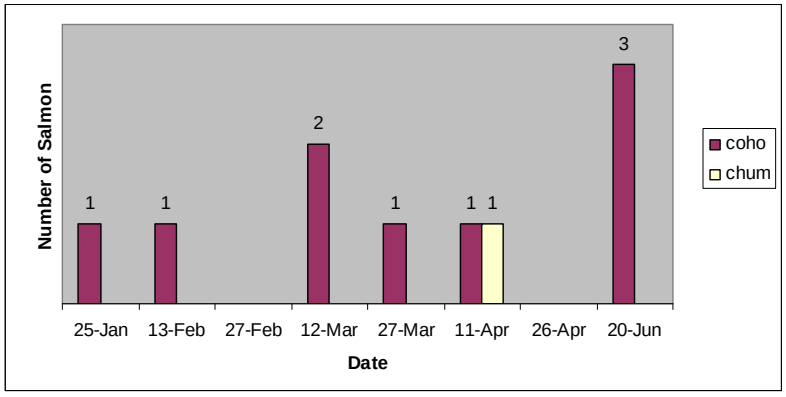
As part of the recent Lewis & Clark National Historic Park expansion, the Conservation Fund purchased 45 acres of pastureland adjacent to the Lewis & Clark River. South slough divides the site, with a pasture on one side and a lower elevation wetland on the other. Prior to the property acquisition, cattle and horses grazed the pasture with unrestricted access into the slough. The restoration activity replaced an undersized tidegate with a 46-foot bridge allowing full tidal inundation and fish access. Selection of the restoration design was based on the goals of returning tidal hydrology to historic inundation levels on the site, increasing the amount of juvenile salmonid rearing habitat in the Youngs Bay basin, and minimizing the risk to the existing county roadbed (Fort Clatsop Road).

Ecological benefits are quantified by monitoring biological and physical parameters. Pre-and post project fish community, fish prey utilization and availability, vegetation, water quality, sediment accretion and channel morphology monitoring have been conducted at the restoration site, with identical data collected at a nearby reference site. The plant community is continuing to shift to native wetland species assemblages. The channel

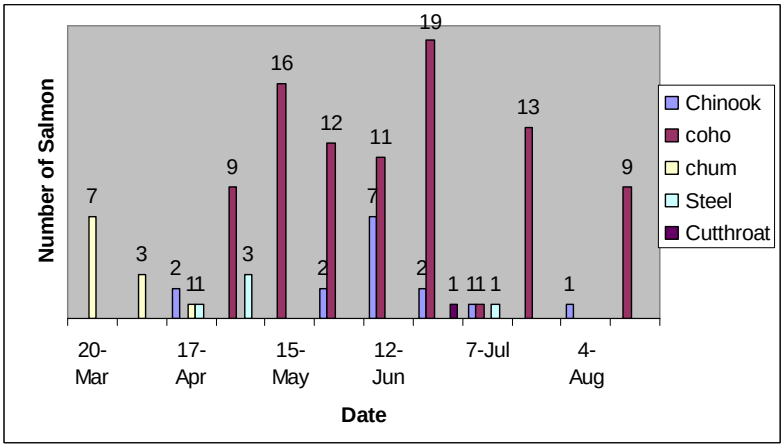
morphology has changed considerably with increased tidal influence. The slough bank along the pasture is starting to erode, gradually lowering the elevation of the pasture to match the elevation of the wetland. Channel forming processes are evident in the pasture side as well, with new channels continuing to form perpendicular to the slough with each high water event. Water quality has also improved with increased tidal inputs, resulting in lower temperatures and increased dissolved oxygen.


The restoration activities resulted in unrestricted fish access to the site, as is demonstrated by the increase in both juvenile salmonid use and diversity in South Slough. The majority of salmon caught pre-restoration were coho, with one chum fry observed. Bi-catch included stickleback, cottids, peamouth chub, and banded killifish. Post-restoration fish community monitoring found coho, chinook, chum, steelhead, and cutthroat utilizing the slough. Chum numbers increased substantially, with coho still remaining the most abundantly caught species. Bi-catch includes stickleback, cottids, peamouth chub, banded killifish, shiner perch, and pumpkinseed sunfish.

The reference site was selected based on the proximity to the restoration site, a history of tidal connectivity, and the site having environmental conditions that support rearing juvenile salmonids. At both the restoration site and the reference site, fish community data is complemented by sampling for prey availability (benthic and fallout) and prey utilization (stomach contents) to qualify salmonid feeding behavior. Thus far, juvenile salmon are eating predominately terrestrial insects that are generated and available on site, indicating that it is a productive rearing and refuge area. Overall, the improved water quality and increased salmon presence and diversity illustrate the success of the habitat reconnection project.




- Relative abundance and seasonal distribution of salmonids observed at Ft. Clatsop South Slough prior to restoration, 2007.




- Relative abundance and seasonal distribution of salmonids observed at Ft. Clatsop South Slough after restoration, 2008.

# Bonneville Power Administration Estuary Habitat Program

## Background

Bonneville Power Administration (BPA) began funding projects to benefit salmonid recovery in the estuary as part of the 2000 Biological Opinion (BiOp) for the continued operation of the Federal Columbia River Power System (FCRPS). BPA's estuary program supports local entities, like Columbia River Estuary Study Taskforce (CREST) and Columbia Land Trust (CLT), as well as state and federal agencies to acquire and restore habitats and to accomplish Research Monitoring and Evaluation (RM&E) activities.

The National Marine Fisheries Service, NOAA Fisheries' 2008 FCRPS BiOp emphasized the contribution of restoration in the estuary toward meeting FCRPS mitigation requirements. This related in part to research and monitoring that was (and continues to be) conducted to validate assumptions regarding juvenile salmonid rearing and migration in the estuary. Several NOAA Fisheries Northwest Fisheries Science Center technical memoranda helped establish this new paradigm (e.g., *Salmon At Rivers End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon* [Bottom et al. 2005] and *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability* [Fresh et al. 2005]).

The 2007 FCRPS Biological Assessment (2007 FCRPS BA) was developed by the BPA and the U.S. Army Corps of Engineers (Action Agencies) using NOAA Fisheries' *Proposed Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (Estuary Module). The Estuary Module was developed using the Northwest Power and Conservation Council's (Council) *Mainstem Lower Columbia River* and *Columbia River Estuary Subbasin Plans* along with NOAA's technical memoranda and other scientific literature. The Action Agencies used the Estuary Module as a foundation for the 2008 FCRPS BiOp because it included estuary-specific actions developed by NOAA Fisheries to address threats to salmonids during rearing and migration in the estuary. Additionally, the Estuary Module includes implementation targets (# of acres, etc.) and estimates of potential salmon survival improvements that can be achieved through implementation of the 23 actions listed in the Estuary Module.

### Estuary Program Goals, Objectives, and Strategy

The goal of BPA's Estuary Program is to meet the juvenile salmonid survival commitments outlined in the 2008 FCRPS BiOp. The overall strategy is to increase access to historical habitats that have been cut off from the system and improve the quality of available habitats for juvenile salmonids. These habitats include, among others, tidally-influenced spruce swamps and freshwater tidal marshes in the lower and upper reaches of the estuary, respectively. The Action Agencies will use information from RM&E to adaptively manage estuary program implementation. The specific Action Agency commitments are expressed as Reasonable and Prudent Alternatives (RPAs) in the 2008 FCRPS Biop. The seven estuary-related RPAs are briefly described below:

**RPA 36. Estuary Habitat Implementation 2007 to 2009** directs the Action Agencies to fund specific actions identified for implementation in 2007-09 as part of a 10 year estuary habitat program.

**RPA 37. Estuary Habitat Implementation 2010-18** directs the Action Agencies to fund additional projects as needed to achieve the total estuary survival benefits identified in the FCRPS BA. RPA 37 directs the Action Agencies to engage the Lower Columbia River Estuary Partnership Science Work Group to identify restoration projects. It also directs them to form an Expert Regional Technical Group (ERTG) '…to support project selection and to estimate survival benefits'.

**RPA 38. Piling and Dike Removal Program** directs the Action Agencies to implement the new program to increase juvenile salmonid access to productive habitat and reduce predation.

**RPA 58. Monitor and Evaluate Fish Performance in the Estuary and Plume** directs the Action Agencies to monitor biological responses and/or environmental attributes relating to smolt survival and fitness; monitor and evaluate life history diversity of salmonid populations; monitor juvenile growth rates and prey resources; monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators.

**RPA 59. Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions** directs the Action Agencies to map bathymetry and topography; establish a hierarchical habitat classification system; develop and index of habitat connectivity; evaluate migration and use through shallow water habitats; and monitor habitat conditions.

**RPA 60. Monitor and Evaluate Habitat Actions in the Estuary** directs the Action Agencies to monitor and evaluate a representative set of habitat projects in the estuary; develop reference sites; evaluate the effects of selected habitat restoration actions relative to reference sites; estimate the cumulative effects of habitat conservation and restoration projects.

**RPA 61. Investigate Estuary/Ocean Critical Uncertainties** directs the Action Agencies to perform research to define the ecological importance of the estuary and plume; define 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 fresh water; continue development of a hydrodynamic numerical model for the estuary and plume.

## Implementing RPAs 36 & 37: Building Capacity and Developing Projects

The Action Agencies are increasing their capacity to implement habitat restoration projects in the estuary. For example, in a recent memorandum of agreement between the Action Agencies and the State of Washington, BPA and the Army Corps became partners with the state to identify and implement restoration projects under the Army Corps' Section 536 ecosystem restoration authority. This new partnership aligns the state's land base with Section 536 funding and mission, and BPA's estuary program to restore habitats on a scale not previously possible.

BPA is also working directly with the Lower Columbia River Estuary Partnership (LCREP), CREST, CLT and others to increase their capacity for identifying, developing, designing, and constructing restoration projects. Additionally, BPA is working directly with these partners to acquire key parcels for restoration. Achievement of the 2008 FCRPS BiOp commitments necessitates these types of investments in order to increase the capacity essential to developing and implementing salmonid habitat restoration

projects in the estuary. This increased capacity is expected to translate into additional opportunities to expand the land base required to implement restoration actions and to develop key partnerships to multiply the number and quality of salmonid habitat restoration projects in the estuary.

## Selecting Estuary Restoration Projects to Achieve 2008 FCRPS BiOp Commitments

The seven 2008 FCRPS BiOp estuary-related RPAs provide a framework for evaluating estuary acquisition and restoration projects. The flow chart in Figure 1 identifies the components of this framework and illustrates the relationship of components to one another. The LCREP Science Work Group and Project Review Committee and the Expert Regional Technical Group (ERTG) provide scientific and implementation input to the Action Agencies to use in determining the appropriateness of a project proposal in assisting them to meet their commitments in the 2008 FCRPS BiOp.

LCREP's Science Work Group and Project Review Committee evaluate the relative value of acquisition or restoration projects using ecosystem criteria. Projects are reviewed and evaluated in terms of implementation certainty, ecosystem-scale benefits, and monitoring sufficiency. The LCREP process (see middle box of flow chart) includes science review and selection based on ecosystem criteria. The ecosystem evaluation criteria were developed and reviewed by the ISRP in 2003. LCREP also evaluates projects using a prioritization framework tool developed by the Pacific Northwest National Laboratories (PNNL) that estimates the level of landscape-level disturbances. The analysis helps identify where landscape processes are intact and where landscape processes support restoration actions.

An ecosystem classification system, currently under development by University of Washington, the US Geological Survey, and LCREP will support historical and current analysis. A set of metrics that can be applied to Columbia River Estuary Ecosystem Classification (CREEC) geomorphic catena are being developed and used to generate juvenile salmonid habitat statistics for historical and current landscape features. These statistics can be generated using various tools, including the relationship of exceedance flows to landscape features, to estimate usable fish habitat potential under multiple flow scenarios. When linked to fish genetics data, habitat availability can be projected based on species, flow, and geographic area. Results of these analyses will allow scientists and restoration practitioners to target specific ESUs for restoration and to compare and contrast historical habitat metrics with current conditions to select project type and location based upon current and past conditions. CREEC will also provide opportunities to analyze monitoring results (fish use data) and extrapolate results to other landscapes. This project is nearing the end of year two of a five year project and is being developed and currently applied to one reach with the goal of applying the analysis to all eight reaches by the end of the project.

The second science-based group is the ERTG. RPA 37 requires ERTG to assign survival benefits to specific projects to meet 2008 FCRPS Biop commitments. ERTG was created in 2009 and assigns survival benefits based upon certainty of success, project benefit criteria, and project contribution to the Estuary Module action targets (see Figure 1 lower middle boxes). ERTG members are actively working to improve the existing method used in the 2007 FCRPS BA by making the assignment of survival benefits more quantitative and repeatable.

Finally, the Action Agencies have developed draft criteria to facilitate funding decisions and to guide implementation (see Figure 1 lower right boxes). These criteria are designed to help process the technical input from LCREP's science work group and ERTG, and to consider 2008 FCRPS Biop policy

considerations. These considerations include: balancing cost, managing risk, and aligning implementation timelines to achieve a balanced project portfolio for near- and long-term achievement of Action Agency commitments.

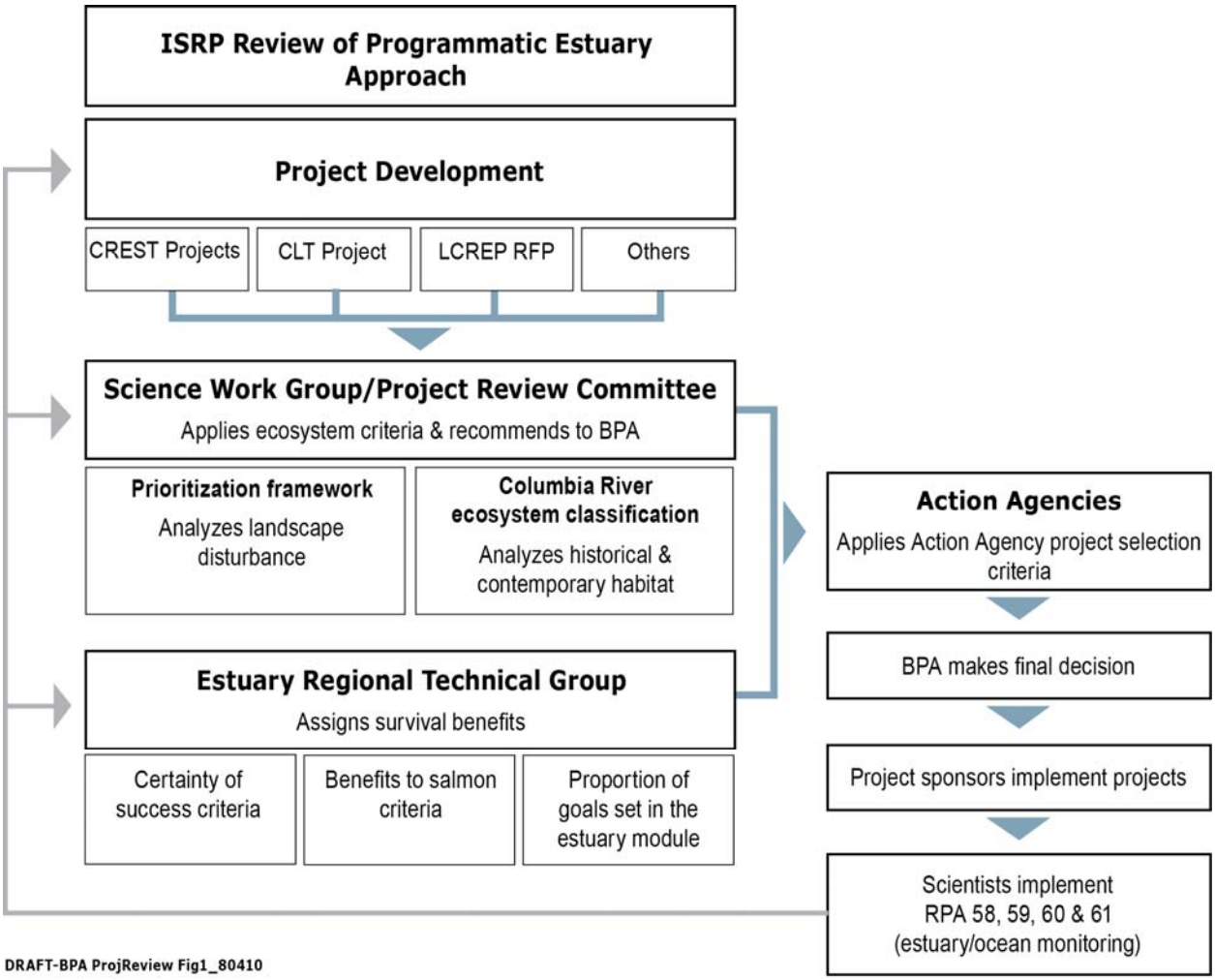



**Figure 1**. **Project Identification and Evaluation Process**

# Summary of Research, Monitoring, and Evaluation (RM&E) for the Federal Columbia River Estuary Habitat Restoration Program

The RM&E for the Federal Columbia River Estuary Habitat Restoration Program is to provide data and information to evaluate progress toward meeting program goals and objectives as outlined in the 2008 BiOp on FCRPS operations. The study area is the floodplain in the lower Columbia River and estuary from Bonneville Dam to the mouth. The primary management questions pertaining to estuary habitat restoration implicit in the BiOp include: 1) Are the estuary habitat actions achieving the expected biological and environmental performance? 2) 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? 3) What are the limiting factors or threats in the estuary/ocean preventing the achievement of desired habitat or fish performance objectives?

The goal of estuary RM&E is to provide pertinent and timely research and monitoring information to planners, implementers, and managers of the Estuary Program. Following the 2008 FCRPS BiOp, estuary RM&E has specific objectives for status and trends monitoring, action effectiveness and critical uncertainties research, implementation/compliance, and synthesis/evaluation (see Attachment 1). Estuary RM&E is conducted within the Estuary Program's adaptive management framework (Figure 2.), which is conducted within the overall adaptive management effort for the 2008 FCRPS Biop.

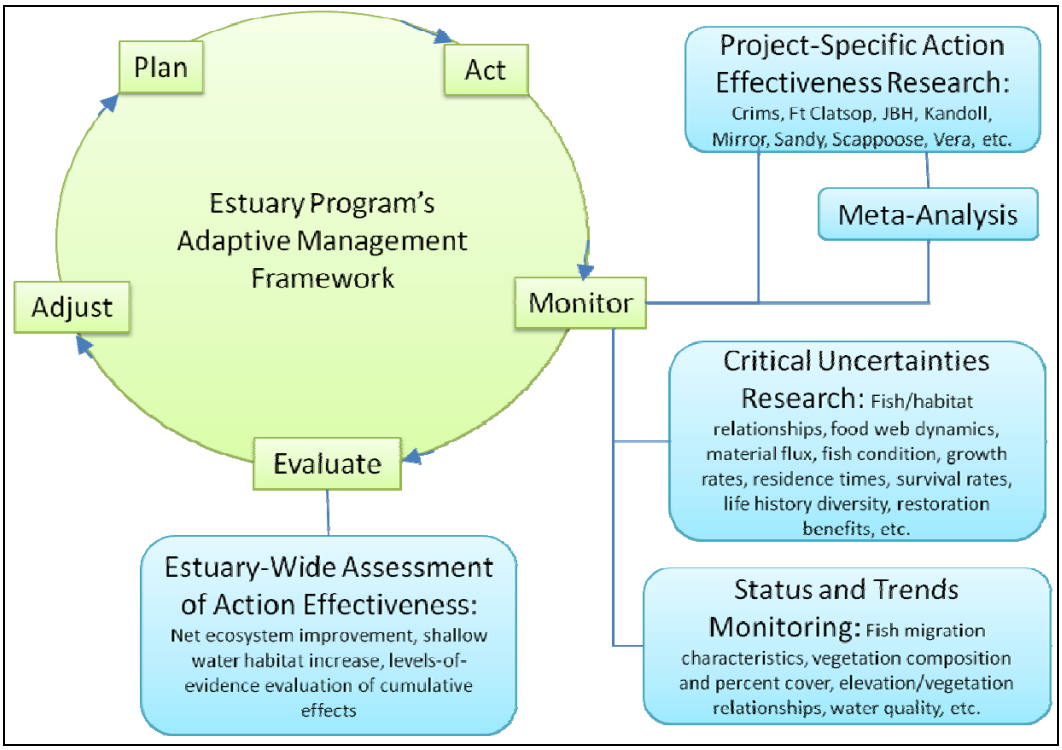



**Figure 2. The Estuary Program's adaptive management framework.**

## Estuary RM&E Plan

To design and implement the estuary RM&E, the Action Agencies and NOAA Fisheries have developed a comprehensive plan (Johnson et al. 2008). Many elements of this plan were incorporated into the 2008 FCRPS BiOp (NMFS 2008; RPAs 58-61). Estuary RM&E includes a *monitoring plan* (Chapter 2 in Johnson et al. 2008) for status and trend monitoring and action effectiveness research objectives; a *research plan* (Chapter 3) for critical uncertainties research objectives; and an *action plan* (Chapter 4) for the implementation/compliance and synthesis and evaluation objectives.

The monitoring plan uses a framework that provides the scientific basis for status and trends monitoring in the estuary. The overall objective of status and trends monitoring is to measure monitored indicators that are ecologically significant to listed salmonids in the estuary, while specific objectives deal with ecosystem controlling factors, structures, and salmonid performance. The Columbia River Estuary Conceptual Model forms a basis for the selection of monitored indicators for each objective (see Attachment 2). A rotational split panel sampling design is being instituted. Data collection methods, the spatial and temporal scale of monitoring, and example protocols are provided in Johnson et al. (2008).

The overall purpose of action effectiveness research is to use quantitative studies to demonstrate how habitat restoration actions affect factors controlling ecosystem structures and processes at site and landscape scales and, in turn, juvenile salmonid performance. Action effectiveness research is conducted whenever possible using a before-after-reference-impact design (Roegner et al. 2009). A network of reference sites has been developed that is crucial to this effort. Effectiveness monitoring data are analyzed using control chart method based on data from a suite of reference and restoration sites and a meta-analysis method. Data collection methods for action effectiveness, as well as the spatial and temporal scale of monitoring and example protocols are provided in (Johnson et al. 2008). Roegner et al. 2009 provide effectiveness monitoring protocols. Action effectiveness research and results will be used to illustrate the affect of management actions in the estuary and to provide feedback to managers for design and selection of the next generation of habitat projects.

The research plan's overall objective is to investigate critical uncertainties in the state-of-the-science in the estuary that are pivotal to understanding fish performance. The focus will be on addressing critical uncertainties underlying the management questions. Uncertainties pertain to the ecological importance of the estuary to salmonids, causal mechanisms affecting survival, early life history in tidal freshwater, effects of hatchery fish on wild fish in the estuary, factors affecting wetting and drying of floodplain habitats, and food web dynamics. Many of the monitored indicators for research are ecosystem processes and linkages between these and ecosystem structures and salmonid performance (Attachment 2). Research results will be applied to risk management and decision-making for the Estuary Program.

The action plan responds to RM&E needs at project- and program-levels. The intent is to implement estuary RM&E across multiple entities whose projects, programs, and processes address the estuary RM&E objectives (Attachment 1). A diverse group of entities implement estuary RM&E, including CREST, NOAA, Oregon Department of Fish and Wildlife, Oregon Health Sciences University, Oregon

State Univeristy, PNNL, Portland State University, US Fish and Wildlife Service, US Geological Service, UW, Washington Department of Fish and Wildlife, and others.

## Estuary RME Implementation

*Coordination processes are well-established.* Federal estuary RM&E is funded mostly by BPA through the Fish and Wildlife Program and the Army Corps through the Anadromous Fish Evaluation Program. Both programs have well-defined program-specific coordination and review processes. The Estuary/Ocean Subgroup for federal RM&E coordinates overall estuary RM&E planning and implementation. In addition, the Estuary Partnership convenes an annual meeting of the Action Agencies, NOAA, Estuary Partnership, and other entities charged with research and monitoring in the estuary. The Action Agencies coordinate estuary RME with other basin-wide RM&E groups, other federal monitoring programs, interested parties, and state and local monitoring efforts.

*Data management, analysis, and dissemination are receiving attention.* Data specifications for estuary RM&E are being developed through Taurus to support a coordinated data management system. Standardized methods for status and trends monitoring and action effectiveness research have been developed to allow comparisons through time for given monitored attributes (Johnson et al. 2008; Roegner et al. 2009). The Estuary Partnership is working to build a data center to house results from status and trends monitoring and action effectiveness research. Such a data center will include a central, web-accessible repository for estuary data, and a publicly accessible homepage with links to a networked system of databases. The intent is to link this system to basin-wide RM&E data to facilitate basin-wide evaluations.

*Information is reported through several avenues.* A biennial estuary conference is convened to evaluate the conduct of the estuary RM&E effort, exchange information, and provide input to managers. Planning is underway to produce a synthesis report of estuary RM&E which would summarize data and provide adaptive management recommendations at the program level for submittal to the Action Agencies, estuary restoration project leaders, and other related entities. The Action Agencies and their partners are working to establish procedures that link decision makers and RM&E practitioners in a manner consistent with basin-wide adaptive management. Such a step is part of the Estuary Program's and the BiOp's adaptive management efforts.

## Closing

The estuary RM&E effort is designed to meet the research and monitoring needs of the Estuary Program in the context of the Program's adaptive management process and 2008 FCRPS BiOp requirements. The significant body of estuary RM&E developed over the last 30 years (Attachment 3) continues to grow and provide support to the Estuary Program. The success and usefulness of estuary RM&E to Estuary Program decision makers depends on dedicated, consistent conduct of RME planning, implementation, data management, reporting, synthesis, and evaluation.

## References


Borde, AB, HL Diefenderfer, SA Zimmerman, NK Sather, and RM Thom. 2009. *Lower Columbia River and Estuary Restoration Reference Site Study 2008 Report.* PNWD-4133. Prepared by Battelle – Pacific Northwest Division, Richland, WA.

Bottom, DL, CA Simenstad, J Burke, AM Baptista, DA Jay, KK Jones, E Casillas, and M Schiewe. 2005. *Salmon at River's End: the Role of the Estuary in the Decline and Recovery of Columbia River Salmon.* NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA. NOAA Technical Memorandum NMFS-NWFSC-68, 246 p.

Dawley, EM, RD Ledgerwood, TH Blahm, CW Sims, JT Durkin, RA Kirn, AE Rankis, G. Monan, and FJ Ossiander. 1986. *Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary, 1966-1983.* Report to Bonneville Power Admin., Portland, OR by NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA. Contract DACW57-85-F-0623, 256 p.

Diefenderfer, HL, GE Johnson, NK Sather, JR Skalski, EM Dawley, and AM Coleman. 2010. *Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary, Annual Report 2009*. PNNL-19410 DRAFT, prepared by the Pacific Northwest National Laboratory, University of Washington for the U.S. Army Corps of Engineers, Portland District. June 2010.

Evans, NR, RM Thom, GD Williams, J Vavrinec, KL Sobocinski, LM Miller, AB Borde, VI Cullinan, JA Ward, CW May, and C Allen. 2006. *Lower Columbia River Restoration Prioritization Framework.* PNWD-3652 prepared by Battelle, Pacific Northwest Division for the Lower Columbia River Estuary Partnership.

Fresh, K, E Casillas, L Johnson, and D Bottom. 2005. *Role of the Estuary in the Recovery Columbia River Basin Salmon and Steelhead: an Evaluation of Selected Factors Ooopulation Viability.* NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA. NOAA Technical Memorandum NMFS-NWFSC-69.

Johnson, GE and HL Diefenderfer (eds.). 2010. *Evaluating Cumulative Ecosystem Response to Restoration Projects in the Lower Columbia River and Estuary, 2009*. PNNL-19440, prepared by Pacific Northwest National Laboratory, Richland, Washington, and the National Marine Fisheries Service, Seattle, Washington, for the U.S. Army Corps of Engineers, Portland District, Portland, OR.

Johnson, GE, RM Thom, AH Whiting, GB Sutherland, T Berquam, BD Ebberts, NM Ricci, JA Southard, and JD Wilcox. 2003. *An Ecosystem-Based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary*. PNNL-14412, final report submitted to the Bonneville Power Administration, Portland, Oregon, November 2003, by Pacific Northwest National Laboratory, Richland, WA.

Johnson, GE, HL Diefenderfer, BD Ebberts, C Tortorici, T Yerxa, J Leary, and J Skalski. 2008. *Research Monitoring and Evaluation for the Federal Columbia River Estuary Program*. PNNL-17300, final

report by the Pacific Northwest National Laboratory, Richland, Washington, for the Bonneville Power Administration, Portland, OR.

Leary, JC, JL Morace, CA Simenstad, JL Burke, TD Counihan, JR Hatten, IR Waite, KL Sobocinski, J Dietrich, F Loge, B Anulacion, J Spromberg, M Arkoosh, and L Johnson. 2005. *Lower Columbia River Ecosystem Monitoring Project Annual Report for Year 2 (September 2004 to August 2005).* Prepared by the Lower Columbia River Estuary Partnership for the Bonneville Power Administration, Portland, OR.

McMichael, GA, JA Vucelick, BJ Bellgraph, TJ Carlson, RL McComas, L Gilbreath, SG Smith, B Sandford, G Matthews, and JW Ferguson. 2007. *A study to estimate salmonid survival through the Columbia River Estuary using acoustic tags, 2005 and 2006 synthesis report.* Technical Memorandum to the U.S. Army Corps of Engineers, Portland District. PNNL-A-54927.

National Marine Fisheries Service. 2006. *Proposed Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*. Prepared by the Lower Columbia River Estuary Partnership for the National Marine Fisheries Service, Portland, OR.

Roegner, GC, DL Bottom, AM Baptista, J Burke, SA Hinton, DA Jay, CA Simenstad, E Casillas, KK Jones. 2004. *Estuarine habitat and juvenile salmon: current and historical linkages in the lower Columbia River and estuary, 2002.* Report of Research by Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration to the U.S. Army Corps of Engineers, Portland, Oregon.

Roegner, GC, HL Diefenderfer, AB Borde, RM Thom, EM Dawley, AH Whiting, SA Zimmerman, and GE Johnson. 2009. *Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary*. NOAA Technical Memorandum NMFS-NWFSC-97, prepared by NOAA Fisheries and Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland District. Seattle, Washington.

Sather, NK, GE Johnson, AJ Storch, DJ Teel, JR Skalski, TA Jones, EM Dawley, SA Zimmerman, AB Borde, C Mallette, and R Farr. 2009. *Ecology of Juvenile Salmon in Shallow Tidal Freshwater Habitats in the Vicinity of the Sandy River Delta, Lower Columbia River, 2008*. PNNL-18450, final report submitted to the Bonneville Power Administration by Pacific Northwest National Laboratory, Oregon Department of Fish and Wildlife, National Marine Fisheries Service, and University of Washington.

Simenstad, CA, JL Burke, IR Waite, TD Counihan, and JR Hatten. 2005. *Lower Columbia River and Estuary Ecosystem Classification: Phase II*. Wetland Ecosystem Team, School Aquat. Fish. Sci., Univ. Wash., and U.S. Geol. Surv., Water Res. Div., Ore. Dist. Off., rep. to Lower Columbia River Estuary Partnership, Portland, OR.

Thom, RM, AB Borde, NR Evans, CW May, GE Johnson, and JA Ward. 2004. *A Conceptual Model for the Lower Columbia River Estuary*. Final report to the U. S. Army Corps of Engineers by Pacific Northwest National Laboratory, Richland, WA.

## Attachment 1: RME Objectives

(from Johnson et al. 2008)

Status and Trends Monitoring: Habitat Conditions[1] – Determine the status and trends of monitored indicators for estuary/ocean conditions that are ecologically significant to listed salmonids in the lower river, estuary, plume, and nearshore ocean.

- Map bathymetry and topography of the estuary as needed for RME.
- Establish a hierarchical habitat classification system based on hydrogeomorphology, 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.
- Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, substrate characteristics, dissolved oxygen, temperature, conductivity, and primary and secondary production at representative locations in the estuary and plume.

Status and Trends Monitoring: Juvenile Salmonid Performance – Determine the status and trends of monitored indicators for juvenile salmonid performance in the estuary and plume.

- Evaluate migration charcateristics, including juvenile salmonid abundance, residence times, growth rates, diets, and prey resources at representative locations in the estuary and plume to understand habitat usage and relative ecological importance of various habitats to juvenile salmonids.
- Monitor and evaluate juvenile salmonid survival from Bonneville Dam through the estuary into the plume.
- Develop an index and monitor and evaluate life history diversity of juvenile salmonid populations at representative locations in the estuary.
- 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 Effectiveness Research[2] -- Using a representative set of projects, monitor and evaluate the effects of habitat restoration actions in the estuary.

- 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. ("Effectiveness Monitoring")

[1] Status and trends monitoring is defined as census or statistically designed monitoring of fish or wildlife populations and/or environmental conditions (i.e., watershed conditions) to assess the current status (at a particular time) or trend (over time) (BPA 2005).

[2] Action effectiveness research is defined as 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 (BPA 2005).

- 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. ("Validation Mon.")

Critical Uncertainties Research[3] – Investigate critical uncertainties in the state-of-the-science in the estuary, plume, and nearshore ocean that are pivotal to understanding estuary/ocean effects on juvenile salmonid performance.

- 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 the early life history of salmon populations in tidal freshwater of the lower Columbia River.
- Investigate the effects of hatchery fish on wild (naturally produced) fish in the estuary.
- Understand the wetting and drying of the floodplain habitats caused by complex hydrodynamic interactions of tides, mainstem and tributary flows, and the effect of the FCRPS on river conditions.

Implementation and Compliance Monitoring – Assess whether projects are being implemented as planned and measure the amount of estuary habitat being conserved and restored annually.

- Determine whether restoration projects were carried out as planned, i.e., whether specified project criteria were met ("Implementation Monitoring").
- Total the amount of estuary habitat conserved and restored annually by habitat type.

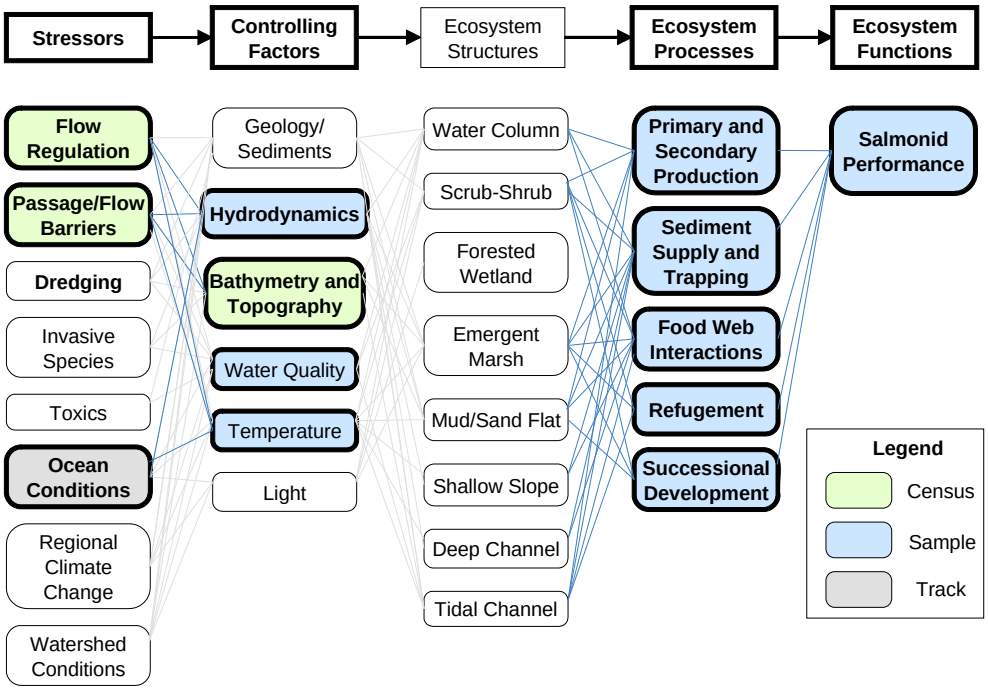
Synthesis and Evaluation -- Synthesize data from Objectives 1-5 and evaluate the Estuary Program within an adaptive management framework.

- Upload, compile, manage, and disseminate project-level data at the Estuary Program level.
- Synthesize the data and periodically report it to the region.
- Use the synthesized data to evaluate the Estuary Program and refine the estuary RME effort as necessary.

[3] Uncertainties research is defined as research to resolve scientific uncertainties regarding the relationships between fish and wildlife health, population performance, habitat conditions, life history, and/or genetic conditions. Uncertainties research referenced herein requires resolution in order to successfully implement the Estuary Program.

## Attachment 2: Columbia River Estuary Conceptual Ecosystem Model

Example conceptual model for action effectiveness research from Appendix B, Johnson et al. (2008) based on Thom et al. (2004).



## Attachment 3: Estuary RME

The following RME efforts and projects, with representative citations, provide essential support the Estuary Program (the list is not intended to be exhaustive):

- Migration characteristics (Dawley et al. 1986)
- Ecosystem-based restoration framework (Johnson et al. 2003)
- Habitat linkages research project (Roegner et al. 2004)
- Conceptual ecosystem model (Thom et al. 2004)
- "Salmon at River's End" (Bottom et al. 2005)
- "Role of the Estuary" (Fresh et al. 2005)
- Ecosystem monitoring project (Leary et al. 2005)
- Habitat classification system (Simenstad et al. 2005)
- Restoration prioritization framework (Evans et al. 2006)
- Post-FCRPS survival research project (McMichael et al. 2007)
- Estuary RME plan (Johnson et al. 2008)
- Reference site network (Borde et al. 2009)
- Effectiveness monitoring protocols (Roegner et al. 2009)
- Tidal freshwater research project (Sather et al. 2009)
- Cumulative effects research project (Johnson and Diefenderfer [eds.] 2010)
- Salmon benefits research project (Diefenderfer et al. 2010)