Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume

DRAFT

Prepared for:
NOAA Fisheries

Prepared by:
Bonneville Power Administration
U.S. Army Corps of Engineers, Portland District
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September 30, 2003

Legal Notice

Cover Photo: View looking downstream with Tenasillahe Island on the right.

Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume

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Summary

The goal of the research, monitoring, and evaluation (RME) program for the Columbia River estuary and plume (CRE&P) is threefold: 1) Status Monitoring -- quantify the status and trends in listed salmon usage and survival in the CRE&P; 2) Action Effectiveness -- quantify the effects of the habitat restoration actions on listed salmon in the CRE&P; and 3) Uncertainties -- resolve uncertainties related to salmon recovery actions in the CRE&P. Thus, RME for the estuary and plume (EP-RME) embodies many of the same elements at Tributary RME, e.g., ecosystem and habitat status monitoring questions (p.7 RME Plan 2003). Action effectiveness research in the CRE&P focuses on habitat restoration, as does the uncertainties research. The EP-RME plan addresses the following objectives.

Status Monitoring Objectives

- What is the ecosystem status of the CRE&P?
- What are the biological features of juvenile salmonid fish populations in the CRE&P, including species composition, spatial and temporal distributions, sizes, age-structure, and life stages?
- What are the survival rates of juvenile salmonid fishes migrating through the CRE?
- What is the water quality in CRE&P salmonid spawning and rearing habitat?
- What is the physical condition of CRE&P fish spawning and rearing habitat?
- What are the status and trends of invasive species in the CRE&P?

Action Effectiveness Research

- Do individual restoration projects in the CRE&P, as implemented, meet the project-specific performance goals? Do the projects collectively meet program goals? If not, is adaptive management in place?
- Are individual restoration projects in the CRE&P effectively changing relevant structural or functional parameters relative to reference and/or control sites, e.g., juvenile salmon usage, water quality, vegetation cover, and surface and subsurface properties and processes?
- Are the habitat restoration projects in the CRE&P, collectively, affecting targeted ecosystem processes that support listed salmon? Does the cumulative effect increase survival of listed salmon?

Uncertainties Research

- What is the significance of the CRE&P to salmon?

- What changes, if any, could be made to FCRPS operations that would improve habitat conditions in the CRE&P?
- What scientifically are the highest priority habitat types for restoration in the CRE?
- What is a scientifically acceptable level of monitoring for the suite of projects within a habitat restoration program?
- Is the offsite mitigation program involving habitat restoration in the CRE working?

The EP-RME plan identifies performance indicators and associated attributes for each objective. Performance indicators are characteristics of the system that are both relevant to a project objective and sensitive to predicted changes in the system. Indicators are often comprised of a suite of attributes. Attributes are the specific variables that are measured to assess the response of the system. Attributes are frequently called “metrics” or “parameters” in other monitoring plans. As an example, the status monitoring objective for biological features includes an indicator for usage which has the attributes of residence time, spatial, distribution, and migration pathways. Many of the same performance indicators developed for status monitoring in the CRE&P are applicable to action effectiveness and uncertainties research, although spatial and temporal scales for sampling may differ.

The draft EP-RME plan does not include performance standards or monitoring methods. Performance standards are specific numerical objective deemed necessary to improve ecosystem function, improve salmon survival, and ultimately result in recovery for listed fish. A performance standard can be expressed as an absolute quantitative target, a change in condition from some baseline, or simply used to verify the proper implementation of a particular management action (i.e., programmatic-level standard). The BiOp, however, did not include performance standards for the CRE&P. The Action Agencies intend to eventually develop performance standards for selected performance indicators. Monitoring methods are not included because of time constraints, but they will be determined in the near future. The EP-RME plan, therefore, has placeholders for performance standards and monitoring methods.

Coverage of the performance indicators by ongoing and newly funded monitoring and research projects in the CRE&P was assessed (also called a gap or needs analysis) by listing all pertinent projects and then linking them to specific performance indicators. Some of the recommendations in the action plan that follows arose from gaps in coverage of the indicators by the projects. Coupled with the coverage assessment, a subjective risk analysis was conducted on whether the proposed projects would suffice to provide data for a given indicator and its associated objective. This process lead to recommendations for EP-RME projects (see main body). One of the recommendations was to include a pilot monitoring site in the estuary, analogous to the pilot monitoring in the Wenatchee and John Day subbasins for Tributary RME. The following recommendations pertain to the EP-RME program:

- Establish performance standards.
- Develop EP-RME data specifications.

- Establish an EP-RME monitoring oversight group.
- Coordinate with other basin-wide RME groups, the Estuary Partnership, other federal monitoring programs, and state and local monitoring efforts.
- Write annual EP-RME summary reports.
- Provide the annual reports to fisheries managers and other decision-makers.

It is important to recognize the following points: 1) funding of actions recommended in this plan will be determined in processes elsewhere, such as the COE Anadromous Fish Evaluation Program and the NPCC Fish and Wildlife Program; 2) this document focuses on listed salmon species, although its ecosystem-based approach necessarily affects other species as well; 3) major habitat areas that may also contribute substantially to stock-specific differential mortality of salmon and steelhead are not addressed in the EP-RME plan include the near shore ocean along the continental shelf to Alaska, and open ocean habitats in the Gulf of Alaska; and 4) this plan does not obligate the BPA and COE to fund all of the monitoring and research recommended in it.

In closing, a proposed timeline for EP-RME has the final plan due on January 31, 2004 with a revised draft of the plan due on December 15, 2003. This schedule will synchronize the EP-RME effort with the overall RME process. EP-RME implementation is scheduled to begin in February 2004. This timeline is subject to approval by the Action Agencies and NOAA Fisheries.

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Preface

The Bonneville Power Administration (BPA), in coordination with the U.S. Army Corps of Engineers (COE) and National Oceanic and Atmospheric Administration (NOAA) Fisheries, originated this project (BPA Project No. 2002-077-000; Contract No. 652). Their goal was to provide coordination and facilitation of activities of the estuary/ocean subgroup (EOS) for research, monitoring, and evaluation (RME) arising from the 2000 National Marine Fisheries Service (now called NOAA Fisheries) Biological Opinion (BiOp) on operation of the Federal Columbia River Power System (FCRPS). Specifically, the EOS was tasked with developing the RME plan for the Columbia River estuary and plume (CRE&P) for BiOp Reasonable and Prudent Alternative (RPA) Action 161. The EOS functions under the auspices of the basin-wide RME planning process to implement the FCRPS BiOp, spearheaded by the federal action agencies (BPA, COE, Bureau of Reclamation) and NOAA Fisheries. The estuary and plume RME (EP-RME) plan contained herein is the result of EOS's efforts to date. The EP-RME plan is written as a stand-alone document, although it eventually will be incorporated into the basin-wide RME plan for BiOp implementation.

During the EOS process, scientists from the Pacific Northwest National Laboratory (PNNL) drafted elements of the plan that were then reviewed by staff from the BPA Fish and Wildlife Division, COE Portland District Environmental Planning Division, and NOAA Fisheries Habitat Conservation Division. The Lower Columbia River Estuary Partnership's Science Work Group, NPCC staff, state and tribal fisheries management agencies and others will review the draft dated September 30, 2003. The Independent Scientific Advisory Board of the Northwest Power and Conservation Council (NPCC) and NOAA Fisheries will also review the EP-RME plan as part of the basin-wide RME plan. The anticipated audience for the EP-RME plan includes entities responsible for, interested in, or affected by research, monitoring, and evaluation in the CRE&P. Timeframes to apply this plan extend from the immediate (2003-2004) to the near-term (2005-2006) to the long-term (2007 and beyond). We anticipate and encourage that the plan be revised as new knowledge and experience are attained.

This draft EP-RME plan (dated September 30, 2003) is a work in progress. The current version of the plan contains substantial new material regarding goals, objectives, performance indicators, monitoring variables, critical uncertainties, existing and planned projects, project coverage, and action planning. Placeholders have been inserted for performance targets, sampling design, data collection and analysis methods, data management, and coordination. A timeline to complete the placeholders is included.

Finally, it is important to recognize the following points.

- Funding of actions recommended in this plan will be determined in processes elsewhere, such as the COE Anadromous Fish Evaluation Program and the NPCC Fish and Wildlife Program.

- This document focuses on listed salmon species, although its ecosystem-based approach necessarily affects other species as well. RME for salmon is best undertaken within the context of other biota and physical processes using an ecosystem perspective.

- Major habitat areas that are not addressed in this plan, or in other RME plans for the Columbia Basin, are the near shore ocean along the continental shelf to Alaska, and the open ocean salmonid habitats in the Gulf of Alaska. These areas may also contribute substantially to stock-specific differential mortality of salmon and steelhead.

- The BPA and COE are not obligated to fund all of the monitoring and research recommended in this plan; i.e., the BPA and COE will not be the only entities funding EP-RME.

Acknowledgments

We gratefully acknowledge contributions to this plan by: E. Braun, K. Larsen, and B. Willis of the COE; J. Geiselman, N. Ricci, and A. Ruger of BPA; R. Thom, J. Slater, and G. Williams of PNNL; C. Peterson of Portland State University; A. Giorgi and T. Hillman of BioAnalysts, Inc.; C. Paulsen; and, E. Casillas and C. Tortorici of NOAA Fisheries.

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Abbreviations and Acronyms

AER – action effectiveness research

BiOp – Biological Opinion

BPA – Bonneville Power Administration

COE – U.S. Army Corps of Engineers

CR – Columbia River

CRE –Columbia River Estuary (RM 0-146)

CRE&P – Columbia River Estuary and Plume

CREST – Columbia River Estuary Study Taskforce

CRFMP – Columbia River Fish Mitigation Project

CUR – critical uncertainty research

ENSO – El Nino Southern Oscillation

EOS – Estuary/Ocean Subgroup (for RME)

EP-RME – Estuary/Plume Research, Monitoring, and Evaluation

EPA – Environmental Protection Agency

ESA – Endangered Species Act

ESU – evolutionarily significant unit

ETM – estuarine turbidity maxima

FCRPS – Federal Columbia River Power System

GI – general investigation

GIS – geographic information system

ISAB – Independent Scientific Advisory Board

LCR – Lower Columbia River

LCREP – Lower Columbia River Estuary Partnership

MHHW – mean higher high water

MLLW – mean lower low water

NMFS – National Marine Fisheries Service (now called NOAA Fisheries)

NOAA – National Oceanic and Atmospheric Administration

NPCC – Northwest Power and Conservation Council (formerly Northwest Power Planning Council)

NRC – National Research Council

ODEQ – Oregon Department of Environmental Quality

PDO – Pacific Decadal Oscillation

PNNL – Pacific Northwest National Laboratory

RM – river mile

RME – research, monitoring, and evaluation

RPA – Reasonable and Prudent Alternative

SARE – Salmon at River's End

SM – status monitoring

SWG – Estuary Partnership's Science Work Group

TBD – to be determined

TRT – Technical Recovery Team

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

WDFW – Wash. Dept. Fish and Wildlife

WRDA – Water Resources Development Act

Glossary

Adaptive management – A process for testing hypotheses through management experiments in natural systems, collecting and interpreting new information, and making changes based on monitoring information to improve the management of ecosystems; i.e., "learning by doing."

Action effectiveness research – Evaluation of how effectively actions specifically designed to aid listed salmonids produce the desired biological and physical response.

Attribute – Frequently called "metric" or "parameter," this is the specific variable that is measured to assess the response of the system, e.g. "percent cover" or "survival."

Conceptual model – A graphical representation or a simple set of diagrams that illustrate a set of relationships among factors important to the function of an ecosystem or its subsystems.

Connectivity – A measure of how connected or spatially continuous a corridor or matrix is.

Critical uncertainties research – Research to address uncertainties in the analytical assessments used in the BiOp (NMFS 2000) and subsequent planned check-in evaluations.

Disturbance – Any relatively discrete event in time that disrupts or alters some portion or portions of an ecosystem. **–**

Ecosystem – A community of organisms in a given area together with their physical environment and its characteristic climate.

Ecosystem function – Ecosystem function is defined as the role the plant and animal species play in the ecosystem,. Including primary production, prey production, refuge, water storage, nutrient cycling, etc.

Ecosystem process – Ecosystem processes are any interaction among physicochemical and biological elements of an ecosystem that involve changes in character or state. -

Ecosystem structure – Ecosystem structure is defined as the types, distribution, abundances, and physical attributes of the plant and animal species comprising the ecosystem.

Effectiveness monitoring – Activities designed and undertaken to assess how well a particular restoration project performs.

Estuarine turbidity maxima – Circulation phenomena in an estuary that traps particles and promotes biogeochemical, microbial and ecological processes that sustain a dominant pathway in the estuary's food web (from http://depts.washington.edu/cretmweb/).

Estuary – The tidally influenced waters of a river. In the Columbia River, the estuary is the portion from the mouth (RM 0) to Bonneville Dam (RM 146).

Habitat – The physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal.

Habitat capacity – A category of habitat assessment metrics including "habitat attributes that promote juvenile salmon production through conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality," for example, invertebrate prey productivity, salinity, temperature, and structural characteristics.

Habitat opportunity – A category of habitat assessment metrics that "appraise the capability of juvenile salmon to access and benefit from the habitat's capacity," for example, tidal elevation and geomorphic features.

Indicator – Characteristic of the system that is both relevant to a project objective and sensitive to predicted changes in the system. Often comprised of a suite of attributes.

Lower Columbia River – The tidally-influenced freshwater part of the estuary from RM 46 to RM 146.

Ocean-type life history – Life history pattern for salmon in which juveniles migrate to sea as subyearlings.

Oligohaline – Water having low salinity.

Performance indicator – see "Indicator."

Performance standard – A specified numerical objective or target deemed necessary to improve ecosystem function, improve salmon survival, and ultimately result in recovery for listed fish. A performance standard can be expressed as an absolute quantitative target, a change in condition from some baseline, or simply used to verify the proper implementation of a particular management action (i.e., programmatic-level standard).

Performance target – Same as "performance standard", except refers to interim performance standards where more an "official standard" has yet to be defined and agreed to.

Plume – The layer of Columbia River water in the nearshore Pacific Ocean.

Protocol – Standardized procedures of an assessment methodology to measure attributes of an ecological system.

Realized function – A category of habitat assessment metrics the "include any direct measures of physiological or behavioral responses that can be attributable to fish occupation of the habitat and that promote fitness and survival," for example, survival, habitat-specific residence time, foraging success and growth.

Standard – see “Performance standard.”

Status monitoring – Activities to monitor trends in the status of the ecosystem and fish populations and conditions in the habitats they use.

Stream-type life history – Life history pattern for salmon in which juveniles migrate to sea as yearlings.

Stressor – A component of a conceptual model. A physical, chemical, or biological entity or process that induces effects on individuals, populations, communities, or ecosystems.

Subarea – A portion of a larger area that has unique characteristics.

Target – see “Performance target.”

1.0 Introduction

1.1 Background and Purpose

Research, monitoring, and evaluation (RME) activities are essential to fulfill the Reasonable and Prudent Alternative (RPA) in the 2000 Biological Opinion (BiOp) on operation of the Federal Columbia River Power System (FCRPS) (National Marine Fisheries Service 2000). The RPA requires that the Action Agencies (AA[1]) develop and implement an RME plan. Since early 2001, the AA have been working with NOAA Fisheries and federal, state, and tribal fisheries agencies to develop a comprehensive RME plan for the Columbia River Basin (called the basin-wide plan). In the draft basin-wide RME plan (RME Plan 2003), research, monitoring, and evaluation activities are focused on the listed salmon and steelhead species in the hierarchical context of the ecosystems, subbasins, and habitats supporting these populations. The basin-wide plan encompasses RME activities in habitats used by juvenile and adult life stages of salmonids including natal streams and tributaries, the mainstem hydrosystem, the estuary, and the Columbia River plume in the nearshore ocean. As a subset of the basin-wide RME effort, the plan contained herein covers BiOp RME in the Columbia River estuary and plume (Figure 1).

Figure 1. Study Area for EP-RME in the Columbia Estuary[2] and Plume

[1] The Action Agencies for the FCRPS BiOp are the Bonneville Power Administration (BPA), the Bureau of Reclamation (BOR), and the Corps of Engineers (COE).

[2] The Columbia River estuary is defined to be the tidally-influenced portion of the river from the mouth to Bonneville Dam (RM 0-146). This is consistent with Bottom et al. (2001) and Lower Columbia River Estuary Partnership (1999).

For the estuary and plume (Figure 1), NMFS (2000) prescribed specific actions and associated RME requirements for offsite mitigation to support survival and recovery of ESA-listed salmonids. (See Appendix A for a complete list BiOp RPA actions related to the CRE&P.) For example, the RPA included the *"…goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats…"* (Action 160, p.9-139), *"…a monitoring and research program to address the estuary objectives of this biological opinion…"* (Action 161, p. 9-141), and *"…develop a compliance monitoring program…"* (Action 163, p. 9-141). Based on RME mandates in the BiOp, this estuary and plume RME (EP-RME) plan is designed to 1) monitor status and trends in the CRE&P ecosystem and its populations of salmonid fishes and their habitats, including measurements of progress toward meeting offsite mitigation requirements in the estuary mandated in the BiOp; 2) assess the effectiveness of habitat restoration[1] actions; and 3) identify uncertainties in salmon recovery efforts in the CRE&P. The following key concepts are applied in the EP-RME plan.

- <u>Status Monitoring</u> – Monitor trends in the status of the ecosystem and fish populations and conditions in the habitats they use. Status monitoring also includes habitat tracking to measure the cumulative amount of habitat for listed salmonids in the estuary and plume improved through specific actions.

- <u>Action Effectiveness Research</u> -- Evaluate how effectively actions specifically designed to aid listed salmonids produce the desired biological and physical responses.

- <u>Uncertainties Research</u>[2] – Seek to resolve uncertainties in the CRE&P knowledge base.

The purpose of this EP-RME *plan* is to provide a scientific basis for the EP-RME *program*. Specifically, the plan will 1) establish RME goals and objectives for the CRE&P; 2) incorporate a conceptual ecosystem model developed separately; 3) develop performance indicators, performance standards, and associated sampling protocols for status monitoring and action effectiveness research; 4) identify uncertainties in the knowledge base, 5) assess coverage of the performance indicators and uncertainties by existing and planned projects; and 6) provide an action plan for EP-RME at both the project and program levels.

Given this purpose, the intended outcome of implementation of the EP-RME plan is two-fold. First, it will provide data on performance of the estuary program so that the AA and NOAA Fisheries can assess whether program goals are being met. And, second, data generated as a

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[1] As used here, habitat restoration includes the suite of strategies that can be applied to improve habitat conditions – restoration, conservation, creation, enhancement, and protection.

[2] *Critical* Uncertainties Research, as used in the BiOp, is defined as research to address uncertainties in the analytical assessments used in the BiOp and subsequent planned check-in evaluations. The only critical uncertainties in the BiOp for the estuary are related to the hydrosystem and are covered in the Hydrosystem RME plan.

result of EP-RME will increase the knowledge-base, resulting in management actions that improve estuary and plume habitats, and hence survival, for listed-salmonids.

1.2 Study Area

A number of publications provide extensive summaries of the CRE&P study area (Figure 2), such as the Salmon at River's End report by Bottom et al. (2001), the channel improvements biological assessment by the COE (2001), the RPA Action 158 action plan by the Berquam et al. (2003), and the RPA Action 159 habitat restoration report by Johnson et al. (2003). The brief information here is intended to provide context for the goals of the EP-RME program.

The Columbia River is the second largest river in the United States, with a watershed of over 660,000 km^2. Historically, unregulated flows were estimated to range from a minimum of 2,237 m^3/s (79,000 cfs) in fall to maximum flood flows of over 28,317 m^3/s (1 million cfs) during spring freshets (Sherwood et al. 1990). Since the 1930's, however, the timing of the Columbia River's discharge has been progressively regulated by the construction of 28 major dams and approximately 100 minor dams that reduce spring freshet flows and increase fall flows. River regulation has lowered sediment inputs by 25-33% of that estimated for the late 1800's and increased water temperatures by several degrees. Annual discharge averages about XXX m^3/s. Because of relatively high flow volumes, the estuary is river-dominated and primarily freshwater influenced, although oceanic tides affect water levels throughout the entire lower reach to Bonneville Dam (RM 146). The Columbia River plume is a dominant factor affecting the coastal oceanography of the central northeast Pacific (Landry and Hickey 1989).

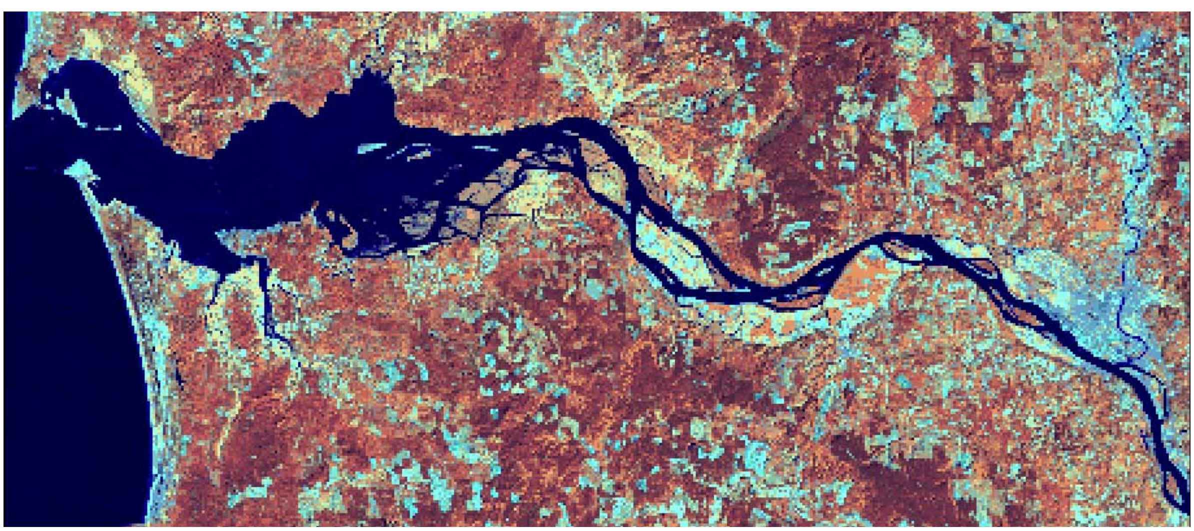

Figure 2. Satellite Photograph of a Portion of the CRE&P Study Area

As recommended in the basin-wide RME plan (RME Plan 2003), the CRE&P study area can be characterized by various classification variables. The CRE&P ecoregion according to the Omnerik classification is Marine West Coast Forests (Omernik 1987, 1995). The study area contains five physiographic provinces: Southern Washington Cascades, Western Cascades, Puget Trough, Willamette Valley, and Coast Ranges (Franklin and Dyrness 1988). The valley type is XXX, its width ranges from XX to XX km, the bottom gradient from RM 0-146 is XX, and containment is XXXX.

1.3 Relationship To Other Estuary RPA Actions and Initiatives

While this EP-RME plan will provide the foundation for the AA to implement RPA Action 161 (Estuary Monitoring Program), it also is related to other estuary RPA actions (Figure 3). Action 158 provides an overall programmatic action plan for the RPA implementation in the estuary (Berquam et al. 2003). This overall plan is under development and will reference EP-RME. Action 159 will result in a restoration plan for habitat of listed-salmonids in the estuary. The draft restoration plan by Johnson et al. (2003) includes guidelines for monitoring and evaluation at the project level. Action 160, mentioned above, calls for implementation of on-the-ground habitat protection and enhancement work. Monitoring and evaluation to assess performance of these projects will fall under action effectiveness research described in EP-RME. Actions 162 and 194 entail modeling efforts, the results of which will be fed into EP-RME as appropriate. Action 195 addresses sources of mortality to listed-salmonid smolts below Bonneville Dam, an important topic for research in EP-RME along with estuarine survival estimation. Actions 196 and 197 involve study of salmonid usage in the estuary and plume, respectively, activities that are necessarily relevant to EP-RME. However, EP-RME does not cover Actions 185, 186, and 187 that deal with phenomena pertaining to the juvenile fish transportation (barging) program that have been hypothesized to manifest themselves in the estuary. (These actions are addressed in the hydrosystem component of the basin-wide RME plan.) In summary, EP-RME will be coordinated and integrated with implementation of estuary RPA actions, so that the estuary program can be adaptively managed.

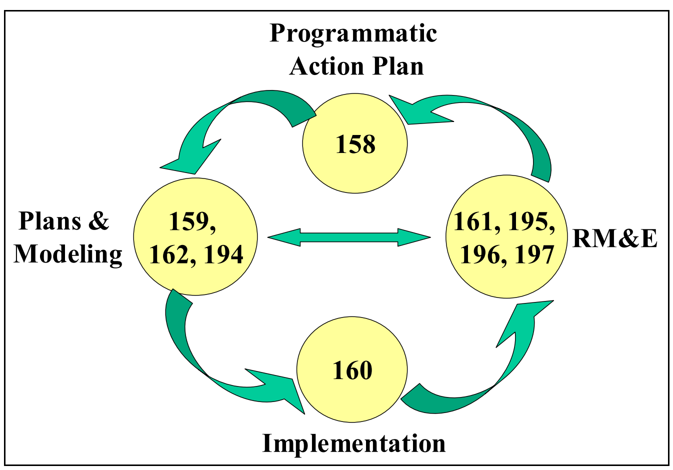

Figure 3. Relationship between EP-RME and Other Relevant RPA Actions. Note that Action 161 is the RME program for the CRE&P.

In addition to particular BiOp RPA actions, the EP-RME plan is closely related to other initiatives in the CRE&P being undertaken by the Lower Columbia River Estuary Partnership and the COE. The Estuary Partnership's "Aquatic Ecosystem Monitoring Strategy" (Estuary Partnership 1998) provides a broad underpinning for the EP-RME plan. For example, the Monitoring Strategy makes specific recommendations for monitoring oversight, data management, monitoring of pollutants, toxics, habitat, exotic species, and primary production. Many of these recommendations are embedded in the EP-RME plan. The Estuary Partnership is also involved in development of the Subbasin Plan for the Columbia River Estuary. This EP-RME may be used to inform this subbasin plan, which is currently under construction and due in spring 2004. On another front, the COE is undertaking a General Investigations Study for Lower Columbia River Ecosystem Restoration. The purpose of this ongoing study is to provide a comprehensive, long-range approach to investigate and recommend appropriate solutions to accomplish ecosystem restoration in the CRE, including wetland/riparian habitat restoration, stream and fisheries improvement, water quality, and water-related infrastructure improvements. The intended outcome of the GI Study is a strategic master plan for long-range, larger projects in the CRE.

1.4 Approach

The EP-RME plan is bounded by the geographic scope of the Columbia River estuary and plume, and by the need to encompass the research, monitoring and evaluation in this geographic area that is required to support implementation of the BiOp (NMFS 2000). The framework provided in this EP-RME plan incorporates existing and planned monitoring programs in the estuary that can be utilized for analyses related to listed salmonids and are thus responsive to the BiOp. The Estuary Partnership's Monitoring Strategy (Estuary Partnership 1998) mentioned above is a sound strategy to build on, although only some of the monitoring prescribed in it has been implemented to date. As with the Estuary Partnership's Monitoring Strategy and basin-wide RME, EP-RME for listed salmonids is best undertaken from an ecosystem perspective, in the context of biological and physical processes, a concept recognized in other RPA actions.

The BiOp contains biological performance standards (see Table 1 for definitions of selected terms) to measure the effectiveness of overall RPA implementation and of specific actions related to the hydrosystem. These performance standards are defined in terms of improvements for salmon populations and for specific life stages (NMFS 2000; Section 9.1.1). In general, NMFS (2000; Section 9.2.2) identified two categories for performance standards: 1) standards intended to evaluate the status of the stocks; and 2) standards intended to evaluate the effectiveness of actions at producing an expected biological or physical response. The standards used to evaluate stock status reflect the biological requirements of the ESUs consistent with maintaining a high likelihood of survival. Recovery standards to be developed by NOAA Fisheries in other forums, such as the Willamette/Lower Columbia Technical Recovery Team process, will likely include measures of abundance, productivity trends, species diversity, and population distribution. While recovery standards are being established, NOAA Fisheries will assess the likelihood of survival and recovery based on estimates of life-stage survival increases and annual population growth rate (i.e., lambda) for each identifiable population in the ESU. However, specific standards are not provided in the BiOp for the CRE&P. Given this absence, a placeholder for them will be included in this EP-RME plan so that they may be inserted at a later date.

Table 1. Definitions of Selected RME Terms

- **Performance Standard**— A specified numerical objective or target deemed necessary to improve ecosystem function, improve salmon survival, and ultimately result in recovery for listed fish. A performance standard can be expressed as an absolute quantitative target, a change in condition from some baseline, or simply used to verify the proper implementation of a particular management action (RME Plan 2003).
- **Performance Target** – Same as "performance standard", except refers to interim performance standards where more an "official standard" has yet to be defined and agreed to.
- **Performance Indicator** –Characteristic of the system that is both relevant to a project objective and sensitive to predicted changes in the system. Usually comprised of a suite of attributes.
- **Attribute** – Frequently called "metric" or "parameter," this is the specific variable that is measured to assess the response of the system, e.g. "percent cover" or "survival."

Because a primary action within the estuary is the restoration of salmonid habitat, the status and trends in available estuarine habitat and the effectiveness of restoration activities are focus points in this plan. To this end, performance indicators (Table 1) for EP-RME (see Sections 4 and 5) were developed based on a review of existing literature and conditions in the estuary, in the context of applicable recommendations for status monitoring, action effectiveness research, and critical uncertainties research in the basin-wide RME plan (RME Plan 2003).

The approach of this EP-RME plan applies the accepted strategies for monitoring estuarine restoration that are referenced throughout this document to the specific goals and conditions of the CRE&P. The design is rooted in goals derived from the BiOp. First, objectives required to meet these goals were developed. Then, performance indicators and associated performance standards (to be determined) that could be used to assess whether the objectives were attained were derived. This standard process of planning to monitor the restoration of aquatic ecosystems is described in Thom and Wellman (1996). Because of the importance of the conceptual model in determining these linkages (e.g., Batiuk et al. 1992), it is expected that the performance indicators will need to be revisited when a more robust conceptual model of the estuary than is currently available is developed. Likewise, in the sense that this EP-RME plan functions as an "umbrella" document for monitoring in the estuary, it should be periodically revised to cover new monitoring efforts and respond to changing program goals.

Partnerships are often critical to the success of restoration programs (Harrington and Feather 1996). As these partnerships develop, coordination is critical to make use of all existing information, maximize efficiencies in budgets and effort, and learn from related projects. Currently, collaborations between local, state and federal agencies, non-governmental organizations, and others working in the Columbia estuary are rapidly developing. The EP-RME plan will assess the coverage provided by various efforts within the defined geographic area relative to program objectives and identify gaps in the knowledge-base.

In conclusion, development of this EP-RME plan progressed in dependent order as follows: Goals >> Objectives >> Performance Indicators >> Monitoring Variables >> Performance Targets >> Methods >> Existing Projects >> Coverage Assessment >> Action Plan Recommendations. For example, the performance indicators are based on the objectives, which are based on the goals. This approach allowed the program goals and objectives to permeate through to the action plan recommendations.

1.5 Introductory Summary

The EP-RME plan culminates in an action plan that is based on status monitoring, action effectiveness research, and uncertainties research (Figure 4). Uncertainties research arises from both status monitoring and action effectiveness research. The action effectiveness research builds from status monitoring because it utilizes a subset of status monitoring indicators. Requirements for status monitoring, action effectiveness research, and uncertainties research drive the EP-RME action plan recommendations. The EP-RME plan reflect these relationships in its organization as follows: Goals (Section 2), Conceptual Model (Section 3), Status Monitoring (Section 4), Action Effectiveness Research (Section 5), Uncertainties Research (Section 6), Action Plan (Section 7), and References (Section 8). This plan will serve as the foundation for the EP-RME program that will monitor performance and provide information to evaluate the AA's Estuary Program and help attain the goals of the basin-wide RME program, FCRPS BiOp elements for the CRE&P, the Columbia Estuary program, and the national estuary program. That is, although BiOp RME mandates were the impetus for this EP-RME plan, this plan is broader than just BiOp RME.

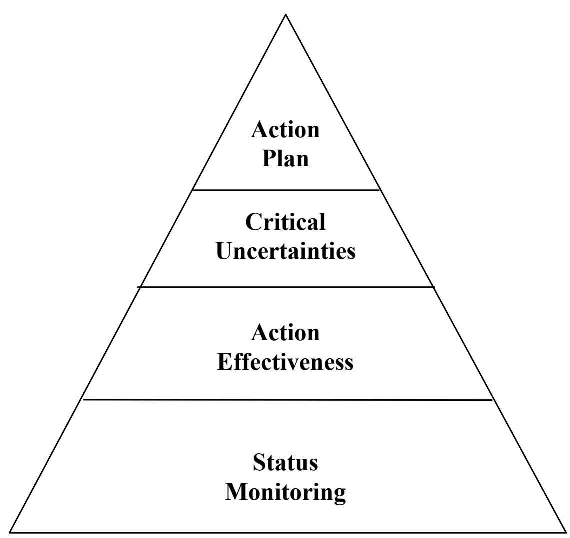

Figure 4. Depiction of the Major Components of EP-RME.

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2.0 Goals

The EP-RME goals are consistent with regional and national goals for estuarine protection and restoration. The applicable EP-RME goals, presented below, lead to the objectives for status monitoring (Section 4), action effectiveness research (Section 5), and uncertainties research (Section 6). The performance indicators and associated monitoring variables, designed to meet the objectives of status monitoring and action effectiveness research will be based on the conceptual ecosystem model for the CRE&P (Section 3).

National Estuary Program Goal

Protect and restore coastal and estuarine ecosystems (National Estuary Program, Estuary Restoration Act of 2000).

Columbia Estuary Program Goal

Protect and restore at least 10,000 acres of wetlands in the lower Columbia River and estuary (Comprehensive Conservation and Management Plan, Lower Columbia River Estuary Partnership 1999).

FCRPS Biological Opinion Goal for the Columbia River Estuary and Plume

Contribute to the increased annual population growth of listed Columbia River Basin salmon species (FCRPS Biological Opinion, NMFS 2000).

RME Program Goals for the Columbia Basin

Provide information needed for assessment of Endangered Species Act listed Columbia Basin salmon and steelhead populations at the 2005 and 2008 year NMFS Biological Opinion check-in evaluations…[and] inform the identification and prioritization of actions that are the most effective toward improved stock performance and provide information for the 2010 NMFS Biological Opinion (RME Plan 2003).

EP-RME Goals for the Columbia River Estuary and Plume

Status Monitoring: Quantify the status and trends in listed salmon usage and survival in the CRE&P.

Action Effectiveness: Quantify the effects of the habitat restoration actions on listed salmon in the CRE&P.

Uncertainties: Resolve uncertainties related to salmon recovery actions in the CRE&P.

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3.0 Conceptual Model

Development of a monitoring program can benefit significantly from a conceptual model of the ecosystem. According to the National Research Council conclusions and recommendations on monitoring ecosystems (1995, 2000) "Indicators should be chosen based on a conceptual model that clearly links stressors (e.g., pollutants, management practices) and indicators with pathways that lead to effects on the structure and function of ecological systems. The "indicators" referred to by the National Research Council are comparable to the "indicators" identified in this EO-RME plan. Performance indicators must be representative of the project or program objectives and be tightly linked, as demonstrated in a conceptual model, to structures, functions or processes expected to change as a result of management actions. Noon (2003) states, "In most cases it will be sufficient to model a restricted, but relevant, component of the system. Thus, a complete model of an ecological system is seldom necessary to proceed with a reliable monitoring program."

3.1 Existing Models

Several ecosystem models for the CRE, each developed for a different purpose, are available. The COE (2001) included a conceptual model for the CRE in the Biological Assessment for the Channel Improvements Project (Appendix E of COE 2001). To be useful to RME planning, this model would need to be more detailed and comprehensive. For example, the food web submodel emphasizes only the pathways involving juvenile salmon, and does not provide the details within subcomponents of the model such as prey resource species. Bottom et al. (2001) present the framework for a conceptual model in *Salmon at River's End* that is guiding research on juvenile salmon usage in the CRE (see NOAA projects in Table 7, Section 7). This model focuses entirely on juvenile salmon, but lacks the linkage to processes that result in the formation, maintenance or destruction of habitats supporting juvenile salmon. Neither of these models addresses the Columbia River plume. For use in estuary/ocean RME and habitat restoration planning, Johnson et al. (2003) recommended the various estuary ecosystem models be critically examined and integrated. This EP-RME plan has not been systematically developed from a conceptual model, as best practices would recommend, because a model of appropriate scope and detail does not at this time exist.

In order to fully link potential degradation of the health of the ecosystem to effects on functions (e.g. for salmon), it is important that the conceptual model for the CRE&P address factors controlling habitat development and maintenance. For habitats supportive of salmon to be self-maintaining in the long run, a clear and explicit understanding of the factors controlling habitat-forming processes is critical. Also, whenever possible, the models should emphasize mechanistic cause and effect relationships and avoid simple correlations. This is especially important in a large and complex ecosystem such as the CRE&P. The basic research underway in the CRE&P should be applied to enhance existing conceptual models. One example is to incorporate into the model improved understanding of the linkage between juvenile salmon habitat usage, residence times, food sources, production rates and energy transfer within the ecosystem. A second example is to address the ecological effects of invasive species on salmonids, such as shad in the estuary. Shad were introduced prior to 1870, make their spawning runs in May-July, and thus overlap in timing with summer run chinook. Shad juveniles are planktivores and, thus, may compete directly with juvenile salmonids in the estuary for available food. Finally, the next-generation model should be peer-reviewed. With comprehensive treatment of components relevant to salmonid habitats, this model would be a critical underpinning of a reliable monitoring program. The status monitoring and action effectiveness indicators identified in this RME plan (Sections 4 and 5, respectively) will be revised as necessary when such a model becomes available. In the meantime, an example application of an existing model is appropriate.

3.2 Example Application

Although its is known that juvenile salmon occur in shallow habitats along the lower Columbia river and estuary, the understanding of why they occur there, and what benefit they might derive from inhabiting these areas is not quantified. Substantial areas of shallow water marshes, tidal channels and swamps have been lost or degraded in the LCRE. Efforts to restore these habitats are being planned. In general, restoration of tidal habitats is expensive, and the results are uncertain. Furthermore, justification of the expense for restoration projects is weakened by a lack of definitive understanding on how shallow water areas may contribute to the overall survival of juvenile salmon. A conceptual model can help guide restoring planning as well as the assessment of the functional performance of restored systems.

As an example application, the model shown in Figure 5 outlines the present conceptual understanding of the aspects of shallow water habitat that contribute to fish use of these areas as well as to how that use contributes to overall survival of the juvenile salmon. The model indicates that survival, in part, is dependent on feeding minus energy costs. Refuge and resting areas contribute to feeding, as does the opportunity to find productive feeding areas. They may also reduce energy loss. The present hypothesis is that current velocities, bathymetry and turbidity all affect the quality of refuge and feeding opportunity (Bottom et al 2001). This hypothesis is currently being evaluated by NOAA Fisheries and others. That work is attempting, among other objectives, to develop numerical relationships between current velocities and juvenile salmonid use of shallow water habitats. These numerical relationships, coupled with numerical modeling of predicted bathymetry and currents, can then be used to optimize restoration of current velocities for salmon feeding.

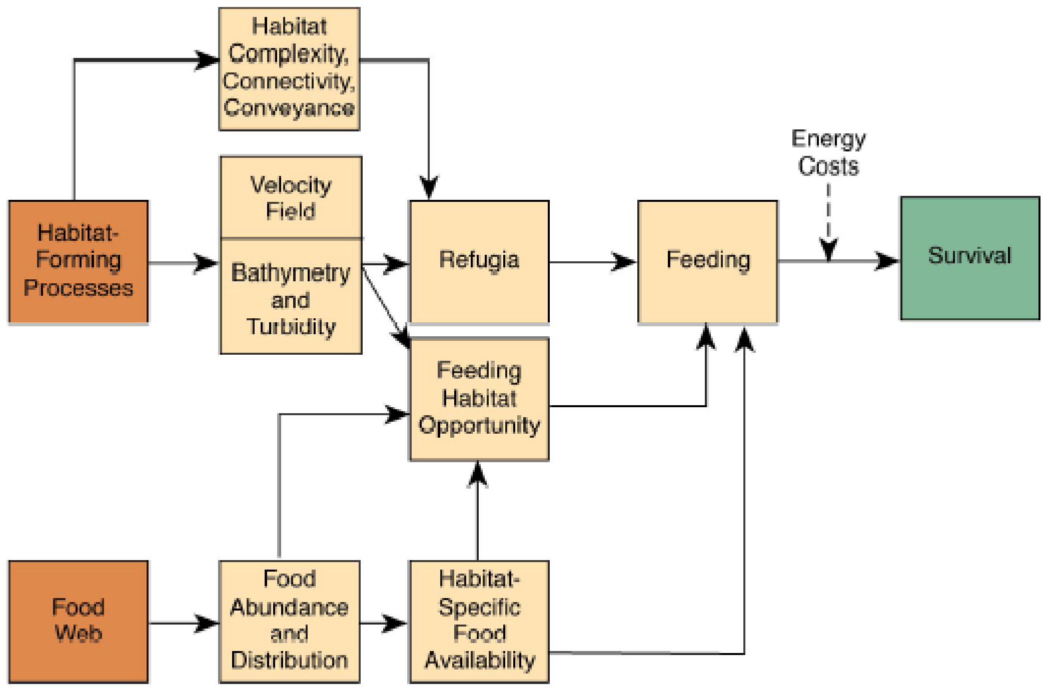

Figure 5. Feeding submodel from Lower Columbia River and Estuary juvenile salmonid model (Appendix E in COE 2001).

The conceptual model provides guidance on monitoring restored areas. For example, its is likely that the research examining the current velocities will result in a range of current velocities optimal for juvenile salmon for selected habitat geomorphologies. In order for this information to be more generally applied, a wider array of habitat conditions needs to be evaluated. In addition, there is considerable uncertainty in our ability to create optimal current velocity conditions trough restoration actions. This is because natural forces that form habitats are not predictable on the scale at which that juvenile salmon operate. Hence, monitoring of restored sites presents several opportunities including the ability to: 1) generalize the understanding of current velocities among a wider array of hydrogeomorphic conditions; 2) verify of the numerical model; and, 3) directly assess whether the restoration project met its goal of providing habitat conditions conducive to salmon feeding and refuge. This information can then be used in an adaptive way to help better design future restoration projects. These data also allow for a more quantitative assessment of losses associated with past actions, as well as the capabil;ity to assess damages to salmon from loss of shallow tidal areas.

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4.0 Status Monitoring

4.1 Definition and Purpose

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 the value of attributes (monitored variables) of certain performance indicators among locations at a given moment in time (snap-shot), or changes in their values across time at a given location (trend). The terminology (indicators and attributes) is consistent with the material on status monitoring in the RME Plan 2003 (p. 38).

4.2 Objectives

The objectives for status monitoring in the CRE&P, although specific to estuarine and plume environments, are consistent with the status monitoring objectives for mainstem and tributary habitats. The first objective (ecosystem status) is broad-scale, responsive to the first level prescribed in the BiOp for RME. The remaining objectives address the second RME level (fish population and habitat status monitoring). Performance indicators and associated attributes (monitoring variables) will be developed to address each of these objectives.

1. What is the <u>ecosystem status</u> of the CRE&P?

   Ecosystem status entails a holistic characterization of selected physical and ecological features of the CRE&P, such as a habitat inventory, geology/soils characterization, land classification, and barriers. An inventory of CRE&P habitats will be based on vegetation cover type, substrate type, topography/bathymetry, land use, and fish passage barriers. Ecosystem features include the hydrograph, water velocities, substrate type, levees, tidegates, floodplain topography, and oceanographic conditions in the plume. An important aspect of this objective will be the status and trends of the quantity, location, and connectivity of the habitats preferentially used by salmonid fishes. Habitat usage may be correlated with hydrodynamics in the CRE&P.

2. What are the <u>biological features</u> of juvenile salmonid fish populations in the CRE&P, including species composition, spatial and temporal distributions, sizes, age-structure, and life stages?

   This biological objective addresses the questions of when juvenile salmonid fishes are present, where they are located, and which fishes are using the CRE&P. This information can be used to characterize life history diversity, which is hypothesized to be important to salmon resiliency (Bottom et al. 2001).

3. What are the survival rates of juvenile salmonid fishes migrating through the CRE?

This objective pertains to juvenile survival over the reach from Bonneville Dam to the river mouth (the Columbia River Estuary). Survival rates are commonly estimated for the hydrosystem from Lower Granite to Bonneville dams (Bickford and Skalski 2000) and, indeed, survival in the mainstem is a key element of status monitoring for Hydrosystem RME. This objective extends these data to the lower 146 miles of the Columbia River where improved survival could help reverse salmon population declines in the Columbia River Basin (Kareiva et al. 2000). Survival will be the toughest, but most important, indicator to accomplish. Methods, although yet to be finalized, may include mark-recapture of juvenile salmonid fishes tagged with acoustic transmitters and analysis of data using the methods developed by Skalski et al. (1998).

4. What is the water quality in CRE&P salmonid spawning and rearing habitat?

Water quality characteristics include temperature, salinity, dissolved oxygen, pH, pollutants, toxics, and nutrients. Water quality directly affects salmonid fish survival.

5. What is the physical condition of CRE&P fish spawning and rearing habitat?

Aspects of the physical condition include accretion rate, groundwater level, surface water level and velocity, reduction/oxygenation potential, and large woody debris. These features are elements of habitats required by salmonid fishes, and their measurement is fundamental to the determination of the quantity and quality of available habitat. This objective is consistent with similar work in hydrosystem and tributary habitats.

6. What are the status and trends of invasive species in the CRE&P?

Invasive plants and animals are a growing concern in the CRE&P (Lower Columbia River Estuary Partnership 1999), because they can negatively impact the ecosystem of salmonid fishes in the CRE&P.

4.3 Performance Indicators

The status monitoring indicators designed to address the objectives listed above are shown in Table 2. Indicators, as defined in Section 1.4, are characteristics of the system that are both relevant to an objective, and sensitive to changes in the system. The significance of these indicators relative to characterization of the CRE&P is described in the "Description" column of the table. The attributes associated with each indicator are also shown. Attributes are used to assess the state of the system relative to the objectives. The attributes must be measurable. A placeholder for performance targets is included. As defined in Section 1.4, performance standards are acceptable states of the system relative to the requirements of salmonid populations. Note that performance standards may not be appropriate for some of the indicators in Table 4, e.g., plume conditions. Thus, it is likely a subset of the indicators will be used. Performance targets will be addressed in FY04.

Table 2. Performance Indicators and Attributes for Status Monitoring

ID.	SM Objective	Indicator	Rationale	Target (TBD)	Attribute	Description
SM 1	Ecosystem status of the CRE&P	Habitat inventory	This indicator provides a detailed characterization of ecosystem structure in the CRE that will be used to prioritize restoration actions and monitor trends in habitat quantity and quality.		Vegetation cover	Provides classification of native and non-native vegetation and can show location of plant communities that support juvenile salmonid rearing habitat and prey base development.
					Geology/soils	Influence ecosystem functionality and sustainability.
					Floodplain topography	Includes upper intertidal and supratidal topographic survey of floodplain geomorphy, surface trends, and impoundment features (dikes, ditches, tidegates, etc.).
					Bathymetry	Shows location and depths of main and side channels.
					Area protected, conserved, restored, enhanced, or created	Provides a way to track habitat actions. Requested by Federal Habitat Team
		Connectivity	This landscape-level indicator shows the linkages between different habitat types in the ecosystem and provides a way to assess the status of ecosystem structure.		Passage barriers	Restrict access by salmonids to wetland habitats. Barriers include dikes, levees, tidegates, culverts. Requested by Federal Habitat Team
					Total edge floodplain and tidal channels.	Provides an interface for transfer of energy between wetlands and the main channel.
		River inflow	The river inflow indicator characterizes the amount of freshwater input to the river-dominated CRE&P.		Hydrograph	Shows daily river discharge at a USGS monitoring station at XXX.
		Plume conditions	This indicator characterizes conditions		Juvenile salmon usage	Indicates temporal and spatial distributions and abundance by species of juvenile salmon.

ID.	SM Objective	Indicator	Rationale	Target (TBD)	Attribute	Description
			in the CR plume in the nearshore ocean, an key environment in the life history of juvenile salmon emigrating from the CR Basin affecting survival and ultimately adult returns and population levels.		Anchovy/herring index	Reflects conditions in the lower estuary for juvenile salmon; the higher the anchovy/herring index, the better conditions are for salmon because predation rates decrease (Emmett et al. 2001)
					Zooplankton prey base	Provides data on the quantity and quality of food available to juvenile salmon during their migration upon exiting the CRE.
					Sea surface temperature (El Nino state)	El Nino is a disruption of the ocean-atmosphere system in the tropical Pacific (Philander 1990) revealed by sea surface temperature and affecting productivity and predator distribution in the nearshore ocean off the CR.
					Pacific decadal oscillation	Is a recurring shift of ocean-atmosphere a climatic regime in the North Pacific Ocean that affects salmon productivity (Mantua et al. 1997).
					Upwelling	Influences the productivity of the nearshore ocean off the CR by bringing deep, nutrient-rich waters up to the surface layer over the continental shelf.
SM 2	Biological features of juvenile salmonid fishes in the CRE&P	Life history diversity	Life history strategies employed by salmonids include variations of the ocean- and stream-type patterns. Life history diversity has decreased in the CRE. An increase in life history diversity will result in an increase the spatial structure (distribution and abundance) of ESA-listed salmonids.		Species composition	Provides data on which salmonid fishes are using the CRE including which stocks.
					Age-structure	Reveals the life history strategy by species.
					Temporal distribution	Provides data on when the fish are present in the CRE. The combination of species composition, age-structure, and temporal distribution characterizes life history diversity.

ID.	SM Objective	Indicator	Rationale	Target (TBD)	Attribute	Description
		Usage	This indicator reveals the importance of the CRE&P to salmonid fishes by showing how they use the area.		Residence time	Shows the amount of time salmonid fishes spend in the CRE&P
					Spatial distribution	Describes where the fish are, i.e., which habitats they are using.
					Migration pathways	Characterize the corridors where fish predominately are found migrating downstream.
		Growth			Growth rate	Calculated as the change in length or weight of the sampled population per unit time.
					Prey availability	Use an invertebrate productivity index
					Foraging success	Based on stomach contents
SM 3	Survival rates of juv. salmonid fishes in CRE&P	Survival	Survival is an important indicator because even small survival increases in CRE&P may aid recovery (Kareiva et al. 2000).		Survival rate	Estimated 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 CRE&P.
		Predation	Terns, northern pikeminnows, seals, sea lions, etc. eat salmon at all life stages, decreasing salmon population sizes.		Predation index	Requested by Federal Habitat Team.
SM 4	Water quality in CRE&P salmonid spawning and rearing habitat	Water quality	This indicator is useful because satisfactory water quality is a key component of aquatic habitat quality.		Temperature	Self-explanatory.
					Salinity	Self-explanatory.
					Dissolved oxygen	Self-explanatory.
					pH	Self-explanatory.
					Nutrients	Nitrogen and phosphorous
					Convent'l pollutants	Need to select an indicator pollutant.
					Toxics	Need to select an indicator toxin, then assess fish tissue and body burden.
SM 5	Physical condition	Physical condition	The physical condition indicator characterizes		Substrate type	Related to the soils variable for ecosystem monitoring.

ID.	SM Objective	Indicator	Rationale	Target (TBD)	Attribute	Description
	of CRE&P fish spawning and rearing habitat		the quality of habitats used by salmonid fishes and is useful for examining changes caused by habitat restoration.		Accretion rates	Reveals sedimentation rates from measurements of prehistoric, early historic, pre-diking, post-diking, and post restoration.
					Reduction/oxygenation potential	Measured from pore water at selected sites and used to evaluate organic accumulation.
					Ground water level	Mapping groundwater surface elev. and trends.
					Large woody debris	Maps of logs with diameter greater than XX cm.
					Water velocity	Self-explanatory
					Water surface elev.	Self-explanatory
SM 6	Invasive species in the CRE&P	Invasive species assessment	Invasive species can inhibit or prevent the restoration of habitat quality and quantity for native species.		Species list	Tracks which invasive species are present.
					Spatial distribution	Describes where the invasives are located.
					Abundance	Provides data on population sizes.

4.4 Data Collection and Analysis Methods

This section will be completed in FY04.

Table 3. Sampling design and methods of measurements to estimate the values of the indicators.

Indicator	Monitoring Extent (TBD)	Monitoring Frequency (TBD)	Monitoring Design (TBD)	Attribute	Monitoring Protocol (TBD)	Comments

5.0 Action Effectiveness Research

5.1 Definition and Purpose

Action effectiveness research is tasked with determining the effects of particular management actions. As applied to the CRE&P[1], the primary management action is habitat restoration. Specifically, research is undertaken to determine the local, ecosystem, and salmon-specific effects of restoration projects. The conclusions generated by this research will inform decision making in the adaptive management process. The fundamental elements of project-specific monitoring for habitat restoration projects can be found in Thom and Wellman (1996) and Rice et al. (2003).

5.2 Objectives

The three objectives for action effective research in the CRE&P concern the habitat restoration actions in the estuary.

1. Do individual restoration projects in the CRE&P, as implemented, meet the project-specific performance goals? Do the projects collectively meet program goals? If not, is adaptive management in place?

    This objective involves the assessment of projects individually and collectively relative to project and program goals, e.g., the degree of function attained in a restored area or the size of habitat restored. Assessment of the implementation of the adaptive management plan in case of failure to meet the goals is also included. This objective is referred to as "implementation monitoring."

2. Are individual restoration projects in the CRE&P effectively changing relevant structural or functional parameters relative to reference and/or control sites, e.g., juvenile salmon usage, water quality, vegetation cover, and surface and subsurface properties and processes?

    Trends in those performance indicators assessed under status and trends monitoring are analyzed to meet this objective: e.g., juvenile salmon usage, water quality, vegetation cover, and surface and subsurface properties and processes. This analysis utilizes a network of reference, control, and status & trends monitoring sites. This objective is referred to as "effectiveness monitoring."

[1] Currently, there are no "actions" being undertaken in the plume. Therefore, action effectiveness in the CRE&P pertains to the estuary only.

3. Are the habitat restoration projects in the CRE&P, collectively, affecting targeted ecosystem processes that support listed salmon? Does the cumulative effect increase survival of listed salmon?

This objective answers the question, "what was the cumulative effect of all habitat restoration efforts in the estuary?" There is not a model for this in the literature and it will require substantial research and development to accomplish this. Variables may include detritis flux, prey resources, survival in restored habitats, and others. The answer to this question is critical to objectively determining whether habitat restoration actions in the estuary are positively affecting salmon. This objective is referred to as "validation monitoring."

5.3 AER Framework and Performance Indicators

To assess the action effectiveness of habitat restoration efforts on the Columbia estuary, and meet the first three objectives identified in Section 5.2, the datasets developed through status monitoring (Section 4) and project-specific monitoring will be subjected to directed analysis. The conceptual framework governing the directed analysis will be the habitat's capacity, opportunity, and realized function (Simenstad and Cordell 2000) with respect to listed stocks of Columbia Basin salmon. The question to be answered to assess effectiveness of habitat restoration actions is as follows: Is the habitat opportunity and capacity adequate to support realized functions throughout the associated life histories?

Three levels of monitoring data will be required to meet the objectives for action effectiveness and thus to answer the question above: project-specific or "implementation monitoring," project-related ecosystem structure or function or "effectiveness monitoring," and regional cumulative effects or "validation monitoring" (Table 4). This is consistent with classifications by MacDonald et al. (1991) utilized in Columbia tributary monitoring protocols by Hillman and Giorgi (2001), and with another major restoration planning effort in the Pacific Northwest region, the Puget Sound nearshore ecosystem (Fresh et al. 2003). To the extent possible, data on the performance indicators involving salmonid populations in Table 4 should be differentiated with respect to life history and stock.

Action effectiveness research in the CRE and the tributaries has some differences and similarities. Spatial scale and habitat diversity are greater in the estuary than the tributary areas, thereby affecting experimental designs. In addition, the aquatic environment in the estuary with changing water surface elevations, water currents, and salinities, among other variables, is more dynamic than it is in the tributaries. The AER subgroup for tributary RME, however, confronted some of the same issues that are inherent for AER in the estuary. For example, control sites will be difficult to identify and maintain through time, and adequate replication and isolation of individual action effects will be difficult to accomplish. The EOS will continue to work with the AER subgroup for RME to make the RME plans for these habitat types consistent when applicable.

Monitoring at two of these levels will be addressed through a) the efforts associated with specific projects and overseen by the coordinators of those projects, and b) the status and trends monitoring at selected long-term monitoring sites on the estuary and reference sites associated with key projects, as described in Section 4. The third level of monitoring, cumulative effects, is not currently covered; however, the Corps recently requested proposals consistent with this need. Coverage for the action effectiveness objectives is discussed in detail in Section 7, Action Plan.

Table 4. Analysis of AER Performance Indicators To Assess Habitat Opportunity, Capacity and Realized Function categories. Shading means the attribute pertains to the category.

ID.	Objective	Indicator	Attribute	Opportunity	Capacity	Function
AER 1	Implementation	Habitat inventory	Vegetation cover			
			Geology/soils			
			Bathymetry			
			Floodplain topography			
			Area (size) restored			
		Connectivity	Passage barriers			
			Total edge of tidal channels			
AER 2	Effectiveness (project-specific)	Life history diversity	Species composition			
			Age-structure			
			Temporal presence			
		Usage	Spatial distribution			
			Migration pathways			
		Growth	Growth rate at restored site			
		Survival	Survival rate			
		Predation	Predation index at restored site			
		Water quality	Temperature			
			Salinity			
			Dissolved oxygen			
			pH			
			Nutrients			
		Physical condition	Accretion rates			
			Redox potential			
			Ground water level			
			Large woody debris			
			Water velocity			
			Water elevation			
		Invasive species	Species			
			Distribution			
			Abundance			
AER 3	Validation	Growth	Growth rate in estuary			
			Prey availability			
			Foraging success			
		Survival	Survival rate in estuary			
		Resilience	Disturbance effect			

To assess action effectiveness, data for monitoring variables associated with the performance indicators relevant to habitat capacity, opportunity and realized function (Table 5) need to be analyzed. Habitat capacity, opportunity and realized function may be viewed as three categories of metrics (Simenstad and Cordell 2000), or for the purposes of this report, three categories of monitoring variables and performance indicators. Structural and functional indicators at the ecosystem and habitat/population levels were listed in Section 4 (Table 2). Candidate indicators for the cumulative effects level are provided below (Table 4). However, these will require directed research establishing their suitability before final selection for CRE monitoring. To facilitate judgments about action effectiveness, the relevant indicators are categorized in Table 4 with respect to the most appropriate of the three areas of analysis. Some attirbutes address more than one indicator. The analysis of habitat capacity uses data from implementation and effectiveness monitoring indicators, and the analysis of realized function uses data from effectiveness and validation indicators. If habitat opportunity and capacity are acceptable relative to historical levels, and realized function is acceptable according to monitoring, this may serve as a surrogate for measurement of the effectiveness of habitat restoration actions in the estuary.

Table 5. Definitions of Selected AER Terms (from Simenstad and Cordell 2000)

- **Habitat Capacity** – A category of habitat assessment metrics including "habitat attributes that promote juvenile salmon production through conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality," for example, invertebrate prey productivity, salinity, temperature, and structural characteristics.
- **Habitat Opportunity** – A category of habitat assessment metrics that "appraise the capability of juvenile salmon to access and benefit from the habitat's capacity," for example, tidal elevation and geomorphic features.
- **Realized Function** – A category of habitat assessment metrics the "include any direct measures of physiological or behavioral responses that can be attributable to fish occupation of the habitat and that promote fitness and survival," for example, survival, habitat-specific residence time, foraging success and growth.

The indicators used in habitat opportunity assessment deserve further discussion. Though only passage barriers and channel edge are shown for the "connectivity" indicator in Table 4, habitat opportunity in fact integrates the restored "habitat area" variable from the habitat inventory indicator; temporal scale, or the period of year in which habitat is available, from the attributes "floodplain topography" and "water level" associated with habitat inventory and hydrodynamics indicators; geomorphic features, the total edge and penetration of tidal channels, also associated with habitat inventory; and water velocity, also associated with hydrodynamics (Simenstad and Cordell 2000).

The analytical method applied to this data can be based on the calculation of "connectivity" described in Hillman and Giorgi (2001), modified for use in the estuary and under restored conditions. Briefly, connectivity would be calculated as the area of estuarine habitat currently accessible within a given geographic area, divided by the area of estuarine habitat historically accessible within the area. Using this calculation, an equivalency or the level that meets the standard goal of restoration, "to restore historical[1] conditions," would be one. However, the second term, the number of days available, also needs to be considered as an absolute number, because if few days are available the habitat is not serving its best function. An estimate can also be made incorporating the temporal factor, which synthesizes factors such as the period when water depth is sufficient for passage, as follows:

$$\frac{\textit{Current Area Avaliable}}{\textit{Historic Area Avaliable}} \times \frac{\textit{Current Days per Year Avaliable}}{\textit{Historic Days per Year Available}} = \textit{Index of acre-days}$$

5.4 Data Collection and Analysis Methods

This section will be completed in FY04.

Table 6. Methods for action effectiveness research.

Indicator	**Monitoring Extent (TBD)**	**Monitoring Frequency (TBD)**	**Monitoring Design (TBD)**	**Attribute**	**Monitoring Protocol (TBD)**	**Comments**

[1] BDE – Heida pls define "historical"

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6.0 Uncertainty Research

The resolution of uncertainties in existing CRE&P knowledge base is fundamental to the implementation of appropriate status monitoring and action effectiveness research. Uncertainties are those pieces of information currently unavailable that managers absolutely require to make informed decisions. Many of the uncertainties presented in this section were identified in the Research Needs Identification Workshop for the Columbia River Estuary (COE and Estuary Partnership 2003), the report on Ecosystem-Based Approach for Restoration Projects (Johnson et al. 2003), and the Salmon at River's End report (Bottom et al. 2001). (In the BiOp, the only *critical* uncertainties research in the CRE&P related to the hydrosystem. Since this subject matter is addressed under Hydrosystem RME, it is not included here.) The key management questions in the CRE&P, with associated uncertainties and research needs, are outlined next.

1. What is the significance of the CRE&P to salmon?

Background – There is a lack of fundamental data on habitat usage, growth, and survival of juvenile salmon in the CRE&P. While researchers are working to fill this void, it is impossible to assess the potential of carrying capacity limitations, if any, during residence in the CRE&P.

Uncertainty 1a – The linkage between habitat conditions and growth and survival of juvenile salmonid fishes.

Research Need – Obtain empirical data on the mechanistic relationship between the effects of physical habitat conditions on juvenile salmon growth and survival.

Uncertainty 1b – Attributes of the estuary and plume that are limiting for the listed salmon populations.

Research Need – Determination of the extent of any carrying capacity limitations for juvenile salmon in the CRE&P.

2. What changes, if any, could be made to FCRPS operations that would improve habitat conditions in the CRE&P?

Background -- Since operation of the hydrosystem generally reduces the magnitude of the spring freshet and increases flows in winter compared to the natural river, returning to a more "natural" state might improve habitat conditions in the CRE&P. Data from Uncertainty No. 1 will be applicable here.

Uncertainty 2a -- The effects of hydrograph changes due to the FCRPS on juvenile salmon habitat structure and function.

Research Needs – Use sediment core samples and depositional modeling to compare late-prehistoric (natural), early-historic (1900-1950) and contemporary (1950-2000) accretion and deposition processes, channel migration, and floodplain development. Use hydrodynamic modeling to examine water velocity regimes and water surface elevations.

Uncertainty 2b – The primary driver of the historical estuarine food web.

Research Need – Use sediment core samples and hydrodynamic modeling to determine the relative contribution of micro- and macro-detritus to the historical estuarine food web.

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

Background – The funding level to restore salmon habitat in the CRE is increasing. It is, therefore, important to base the prioritization of projects on the best available scientific information. For example, usage of CRE&P habitats by listed salmon with diverse life histories is a data gap in the status or baseline information that is critical to resolve if trends in this important indicator are to be established as restoration efforts progress. This uncertainty is related to Uncertainty No. 1 and 2.

Uncertainty 3a – Habitat usage by juvenile salmon in the tidal freshwater reach of the CRE (RM 46-146).

Research Need – Monitor juvenile abundance, distribution, residence time, and growth in the tidal freshwater reach.

Uncertainty 3b – Spatial and temporal usage of CRE&P habitats by listed salmon with various life histories.

Research Need – Investigate life history diversity associated with habitats in the CRE&P.

Uncertainty 3c – Accessibility of habitat to juvenile salmon.

Research Need – Identify an acceptable index of connectivity and apply it to the CRE.

4. What is a scientifically acceptable level of monitoring for the suite of projects within a habitat restoration program?

Background – Funds can be limited for pre- and post-construction monitoring. Therefore, this management question examines how best to use these resources.

Uncertainty 4a – The basic set of monitoring variables that must be implemented for a given type of restoration project.

Research Need – Prioritize monitoring variables by type of project.

Uncertainty 4b – Validity of applying results from an intensively monitored project to unmonitored projects of the same type.

Research Need – Assess transferability and predictability of project effects, i.e., site-specificity of project effects.

5. Is the offsite mitigation program involving habitat restoration in the CRE working?

Background – The BiOp RPA includes habitat improvement actions in the tributaries and estuary to help mitigate for the effects of FCRPS operations. To make an informed decision about the effectiveness of this strategy, managers need data on the biological effects of the CRE habitat restoration program, i.e., knowledge of whether or not it improves salmon survival.

Uncertainty 5 – Measurements of cumulative effects of habitat restoration projects on CRE ecosystem functionality.

Research Need – Develop method and data to measure cumulative effects of multiple restoration projects on variables representing ecosystem functionality.

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7.0 Action Plan

The purpose of this section is to provide an action plan for RME in the CRE&P. The action plan starts with a project-level assessment of how well ongoing and planned projects meet EP-RME objectives (see objectives for SM in Table 2, AER in Table 4, and UR in Section 6). Then, coverage of program-level elements, such as data management, is assessed. A risk assessment follows, which leads to recommended actions at both the project and program levels.

7.1 Project-Level Assessment

7.1.1 Project Inventory

Twenty-four projects related to EP-RME are ongoing or have received funding commitments and are scheduled to start before the end of FY2003 (Table 7). The projects were categorized and sorted by type, with the number of projects of a given type in parentheses, as follows: Status Monitoring (12); both Status Monitoring and Critical Uncertainty Research (3); Action Effectiveness Research (5); and Uncertainty Research (4). Of the 15 projects involving status monitoring, six deal with juvenile salmon in the CRE&P, five pertain to water quality or discharge, two are for habitat/bathymetry mapping, one tracks status of restoration, and one addresses invasive species. The funding agencies include the BPA, COE, ODEQ, and USGS. Project leads include federal, state, and local agencies and non-governmental organizations.

Currently, coordination among the projects occurs to varying degrees. For example, P4 and P19 are closely coordinated because the same entity is performing the research. On the other hand, the ongoing water quality monitoring by P10 is somewhat independent of EP-RME because it has a separate primary mission. By presenting the project inventory and using it herein, the EP-RME plan is attempting to provide coordination. Thus, it is evident EP-RME effort is well underway, as shown by sampling locations for some of the EP-RME projects (Figure 6). The Action Agencies are working to coordinate these projects to form a cohesive EP-RME program.

7.1.2 Project Coverage

The action plan for EP-RME is based on a coverage assessment, or gap analysis, of the needs for status monitoring, action effectiveness research, and critical uncertainties research (Tables 2 and 4, and Section 6, respectively) relative to the ongoing and planned projects (Table 7). Although this coverage assessment is subjective, it does reveal gaps in coverage, implying incomplete implementation of EP-RME. Coverage of the SM and AER indicators ranges from negligible to complete (Table 8). Coverage of the uncertainties is either negligible or incomplete (Table 9).

Also, apparently there is no formal sampling for salmonid fishes upstream of Jones Beach (~RM 46) (Figure 5). In both tables, there are projects still in the planning stages or just getting started that should contribute substantially to EP-RME when they are underway.

Table 7. Projects Addressing EP-RME. Identification numbers for SM objectives, AER objectives, and uncertainties are presented in Tables 2, 4, and 6, respectively.

ID.	Title	Project Type	Project No.	Fund Source	Lead Entity	EP-RME Objectives	Indicators
P1	Implement The Habitat Restoration Program For The LCRE	SM	2003-011-00	BPA	Estuary Partnership	SM 1 AER 1	Habitat inventory
P2	Survival And Growth Of Juvenile Salmonids In The Columbia River Plume	SM, UR	1998-014-00	BPA	NOAA/ NWFSC	SM 1 U 3	Plume conditions, life history diversity, usage, growth
P3	Sampling PIT Tagged Juvenile Salmonids Migrating In The Columbia River Estuary	SM, CUR	BPS-00-11	COEP	NOAA/ NWFSC	SM 2	Life history diversity, growth
P4	Estuarine Habitat And Juvenile Salmon – Current And Historical Linkages	SM, UR	EST-02-02	COE	NOAA/ NWFSC	SM 1, 2, 4, 5 U 1, 4	Hab. Inventory, life history diversity, usage, growth, water quality, physical cond.
P5	Total Dissolved Gas Monitoring	SM	XXX	COE	COE	SM 4	Water quality
P6	Baitfish/Salmonid Marine Survival Relationships In The CRE	SM	XXX	NOAA	NOAA/ NWFSC	SM 1, 3, 4	Plume conditions, survival, water quality
P7	CRE Habitat Mapping	SM	2002-012-00	BPA/COE	Estuary Partnership/ Earth Designs	SM1 AER 1 U3	Habitat inventory
P8	Lower Columbia River And Columbia River Estuary Ecosystem Monitoring	SM	2003-007-00	BPA	Estuary Partnership	SM 1, 2, 4	Life history diversity, usage, growth, water quality
P9	Additional Monitoring Of Habitat Usage By Juvenile Salmon	SM	XXX	COE	NOAA	SM 2	Life history diversity, usage, growth
P10	Ambient Water Quality Monitoring	SM	XXX	ODEQ	ODEQ	SM 4	Water quality
P11	Lower Col. R. Aquatic Nonindigenous Species Survey	SM	XXXX	Coast Guard	PSU	SM 6	Invasive species assessment
P12	Long-Term Water Quality Monitoring	SM	???	USGS	USGS	SM 4	Water quality
P13	Hydrograph	SM	???	USGS	USGS	SM 1	Hydrograph
P14	Blind Slough Restoration Project - Brownsmead, Oregon	AER	2003-015-00	BPA	CREST	AER 2	Life history diversity, usage, growth, physical cond., invasive spp.

ID.	Title	Project Type	Project No.	Fund Source	Lead Entity	EP-RME Objectives	Indicators
P15	Effectiveness Monitoring Of The Chinook River Estuary Restoration Project.	AER	2003-006-00	BPA	Sea Resources	AER 2	Life history diversity, usage, growth, physical cond., invasive spp.
P16	Evaluation Of Cumulative Ecosystem Response To Restoration	AER	EST-04-NEW	COE	TBD	AER 3 U 3, 5	Life history diversity, usage, growth, physical cond., invasive spp.
P17	Preserve And Restore CRE Islands To Enhance Juvenile Salmonid And Columbia Deer Habitat.	AER	2003-0008-00	COE	USGS-BRD	AER 2	Life history diversity, usage, growth, physical cond., invasive spp.
P18	Acoustic Telemetry On Continental Shelf	SM	2000-076-00	BPA	Kintama	SM 1	Plume conditions
P19	Historic Habitat Opportunities And Food-Web Linkages Of Juvenile Salmon In The Columbia River Estuary: Implications For Managing Flows And Restoration	UR	2003-010-00	BPA	NOAA	SM 1, 2, 4, 5 U 1, 3	Habitat inventory, life history diversity, usage, growth, water quality physical cond.,
P20	Evaluation Of The Relationship Among Time Of Ocean Entry, Physical, And Biological Characteristics Of The Estuary And Plume Environment And Adult Return Rates	UR	EST-02-03	COE	NOAA	SM 2 U 3	Life history diversity
P21	Estimation Of Salmon Survival Using Miniature Acoustic Tags	UR	EST-02-01	COE	NOAA/ PNNL	SM 2, 3 U 3	Life history diversity, usage, survival
P22	Evaluation Of Migration And Survival Of Juvenile Steelhead And Fall Chinook Following Transportation	UR	TPE-W-00-01	COE	OSU	SM 2, 3	Life history diversity, usage, survival
P23	Bathymetric survey RM 3-40	SM	XXX	COE	XXX	SM 1	Bathymetry
P24	Crims Is. baseline fisheries survey	AER	XXX	COE	USGS	AER 2	Life history diversity, usage

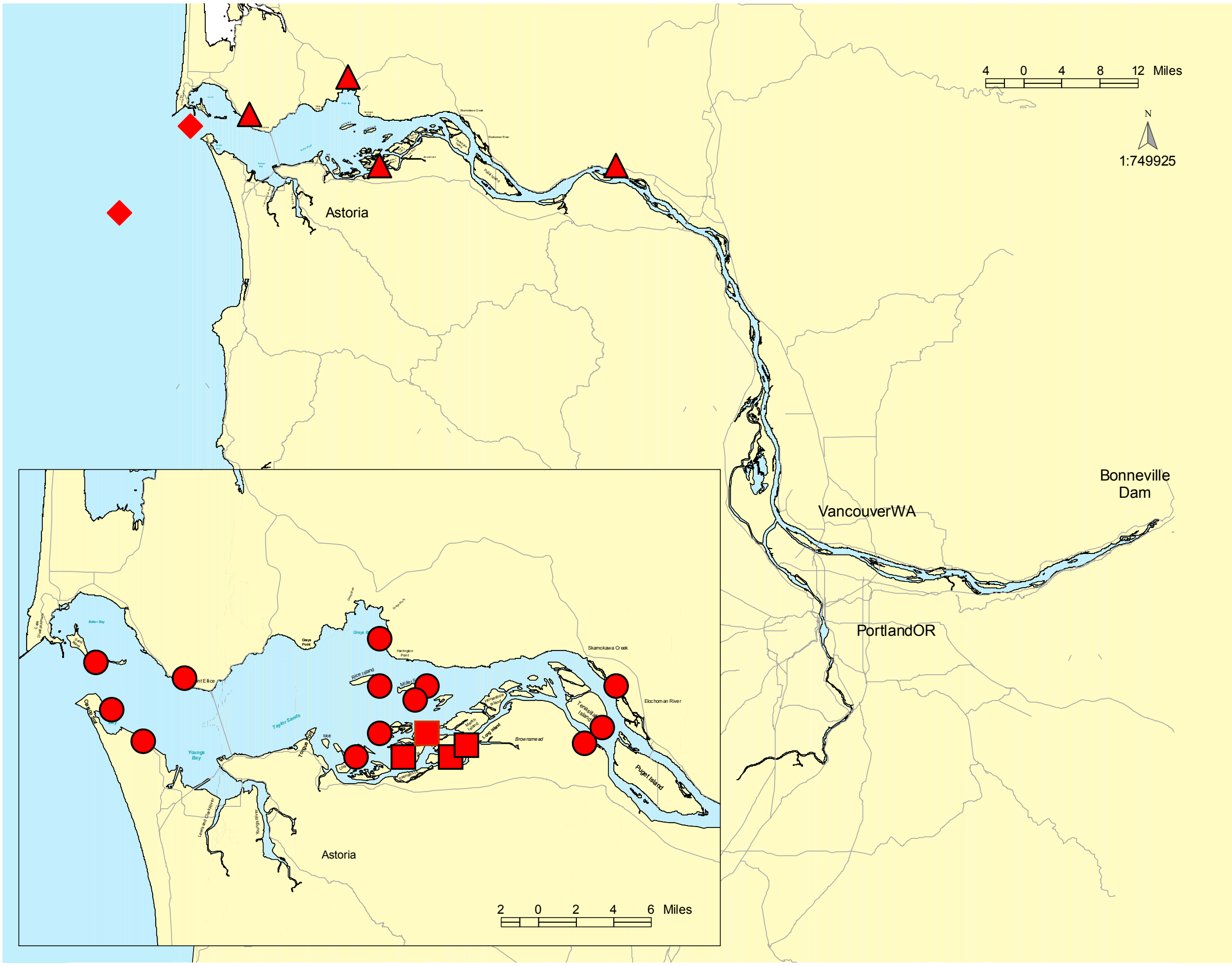

Figure 6. Map of CRE&P Study Area Showing Biological Sampling Locations. **[TO BE COMPLETED LATER]**

▲= habitat restoration sites with AER; ● = beach seine sites for SM; ■ = marsh sites for CUR; ◆= purse seine or trawl sites

Table 8. Coverage by Projects (see Table 7) of the EP-RME Status Monitoring and Action Effectiveness Research Indicators (see Table 2). The symbols represent coverage as follows: ● complete, routine; ○ complete coverage, but data still in pipeline; ⊙ incomplete, project exists but not started or no data yet; ◯ negligible or no activities; ?? unknown. [[reorder by type + include P23 and P24]]

				Projects																					
			Type	SM	SM&UR			SM									AER				SM	UR			
Indicator	**Cov.**	**Attribute**	**Cov.**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**P19**	**P20**	**P21**	**P22**
Habitat inventory	⊙	Veg. cover	○																						
		Geology/soils	??																						
		Floodplain topo.	??																						
		Bathymetry	○																						
		Area restored	⊙																						
Connectivity	⊙	Passage barriers	??																						
		Total chan. edge	⊙																						
River inflow	●	Hydrograph	●																						
Plume conditions	○	Juvenile usage	○																						
		Anchovy/herring	○																						
		Zooplankton	○																						
		Surface temp.	●																						
		PDO	●																						
		Upwelling	●																						
Life history diversity	○	Species comp.	○																						
		Age-structure	○																						
		Temp. distrib.	○																						
Usage	⊙	Residence time	⊙																						
		Spatial distrib.	⊙																						
		Migration paths	⊙																						
Growth	○	Growth rate	○																						

				Projects																					
			Type	**SM**	**SM&UR**			**SM**									**AER**				**SM**	**UR**			
Indicator	**Cov.**	**Attribute**	**Cov.**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**P19**	**P20**	**P21**	**P22**
Resilience	[??]	Disturbance effect	[??]																						
Survival	⭘	Survival rate	⭘																						
Predation	○	Predation index	○																						
Water quality	[??]	Temperature	⭘																						
		Salinity	⭘																						
		Diss. oxygen	⭘																						
		pH	⭘																						
		Nutrients	[??]																						
		Pollutants	[??]																						
		Toxics	⊙																						
Physical condition	[??]	Substrate type	[??]																						
		Accretion rates	[??]																						
		Redox potential	[??]																						
		Ground water	[??]																						
		Woody debris	○																						
		Water velocity	⭘																						
		Water elevation	⭘																						
Invasive species assessment	⊙	Species list	⊙																						
		Spatial distrib.	⊙																						
		Abundance	⊙																						

● complete, routine; ⭘ complete, but need data; ⊙ incomplete; ○ negligible, [??] unknown

Table 9. Coverage by Projects (see Table 7) of the EP-RME Uncertainties (see Section 6). The symbols represent coverage as follows: ● complete, routine; ⭘ complete coverage, but data still in pipeline; ⊙ incomplete, project exists but not started or no data yet; ◯ negligible or no activities; ?? unknown.

No.	Uncertainty	Cov.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23
U1a	Effects on habitat/survival	⊙																							
U1b	Limiting attributes	⊙																							
U2a	Hydrograph effects	⊙																							
U2b	Food web drivers	⊙																							
U3a	Tidal freshwater habitat usage	◯																							
U3b	Habitat usage by life history type	⊙																							
U3c	Habitat accessibility	⊙																							
U4a	Monitoring var's	⊙																							
U4b	Monitoring data transferability	◯																							
U5	Cumulative restoration effects	⊙																							

7.1.3 Risk Assessment

Risk assessments were performed separately for status monitoring, action effectiveness research, and uncertainties research. "Risk" as used here means the likelihood that programs goals and objectives will *not* be met if pertinent data are not available. The risk assessment will be used to help prioritize recommendations in the action plan (Section 7.4).

Status Monitoring

To help develop the EP-RME action plan, the status monitoring indicators (Table 2) were subjected to a risk assessment. First, we subjectively determined the current knowledge-level, presented as "data disparity", using the project inventory (Table 7). Then, we assessed the vulnerability to meeting the SM objectives if there are few data. Highest priority in the action plan will be for indicators with relatively high data disparity in combination with relatively high vulnerability, i.e., high risk scores.

The status monitoring indicator with the highest risk was survival (Table 10). Just below survival came habitat inventory, connectivity, habitat usage, predation, physical condition, and invasive species. The lowest risk was for river inflow.

Table 10. Risk assessment for indicators addressing status monitoring objectives. Codes and scores are L = low = 1, M = medium = 2, and H = high = 3. The overall score is the sum of the scores for data disparity and vulnerability.

SM Objective	Indicator	Data Disparity	Vulnerability To Meeting Objective	Score
Ecosystem Status	Habitat Inventory	**M** Some available data, with more in the pipeline	**H** Ecosystem status cannot be assessed without a habitat inventory	**5**
	Connectivity	**H** No comprehensive data	**M** Key concept in the ecologically-based approach to EP-RME	**5**
	River Inflow	**L** Well documented	**M** Key parameter in the ecologically-based approach to EP-RME	**3**
	Plume Conditions	**L** Data collected for EP-RME projects and others	**H** Plume and ocean conditions provide context basin-wide	**4**
Biological Features	Life History Diversity	**M** Fairly well-established	**M** Important aspect of basin-wide CR salmon population status	**4**
	Habitat Usage	**H** Some data available, but need more	**M** More important to AER than SM	**5**
	Growth	**H** Same as usage	**L** Not essential for SM	**4**
Survival	Survival	**H**	**H**	**6**

		Methods under devel.	A fundamental indicator for SM	
	Predation	**H** Besides avian predation in the lower CRE, not a lot known about predation	**M** To understand survival data, need to understand predation	**5**
Water Quality	Water Quality	**L** Many existing water quality monitoring efforts, but need to coordinate	**H** Basic data	**4**
Physical Condition	Physical Condition	**H** Most data from models, need more field data	**M** Basic data	**5**
Invasive Species	Invasive Species	**H** Underway, but needs to be expanded	**M** Basic data	**5**

Action Effectiveness Research

A risk assessment for the indicators addressing action effectiveness research was performed using the same approach as that for the status monitoring indicators. The result was that most of the AER indicators were at risk (Table 11). Action effectiveness research as the project- and program levels for EP-RME is necessary and will be included in the action plan recommendations.

Table 11. Risk assessment for indicators addressing status monitoring objectives. Codes and scores are L = low = 1, M = medium = 2, and H = high = 3. The overall score is the sum of the scores for data disparity and vulnerability. ***DRAFT***

AER Objective	Indicator	Data Disparity	Vulnerability To Meeting Objective	Score
Implementation	Habitat Inventory	**M** Need more data and need synthesis and summarization	**H** Implementation cannot be assessed without a habitat inventory	**5**
	Connectivity	**H** No comprehensive data	**H** Key concept in the ecologically-based approach to EP-RME	**6**
Effectiveness (restoration project-specific)	All in Table 4	**H** Need well-designed, project monitoring	**H** Cannot assess effectiveness without data for the AER indicators in Table 4	**6**
Validation	Growth	**???** **Heida??**	**???** **Heida??**	
	Survival	**???** **Heida??**	**???** **Heida??**	
	Resilience	**???** **Heida??**	**???** **Heida??**	

Uncertainties Research

What is the potential impact to achieving the Estuary Program's goals (see Section 2) if a given uncertainty is not resolved satisfactorily? Since the uncertainties arose from the key management questions, it is not surprising that risk was on the high side (Table 12). The subjective difference between "High" and "Medium" risk will be useful when critical uncertainties research is prioritized in the action plan recommendations (below).

Table 12. Risk levels for the Uncertainties. As used here, risk is the potential impact to attaining the Estuary RME Program goal if the uncertainty is not resolved. Risk levels: H = high, M = medium, and L = low.

No.	Name	Risk	Comment
U1a	Hydrographic effects on habitat and survival linkages	**H**	Like CU1b, this relationship is fundamental to prioritization of actions to improve survival. Cannot address U2a without U1a.
U1b	Limiting attributes	**M**	Knowledge of limiting factors may lead to more effective resource allocation.
U2a	Hydrograph effects	**H**	Understanding hydrosystem effects could lead to actions that might significantly aid recovery.
U2b	Food web driver	**H**	Fundamental data on estuary ecosystem.
U3a	Tidal freshwater habitat usage	**H**	This 100-mile stretch of the estuary remains largely unexplored and could be an important place to attain survival improvement.
U3b	Habitat usage by life history type	**H**	This is a key driver for the CRE restoration program
U3c	Habitat connectivity	**H**	An increase in the accessibility of habitat to listed salmon is one primary purpose of restoration methods, such as dike breaches, being employed in the estuary. A suitable index of connectivity must be identified to enable baseline data and trends in the expected improvements to connectivity to be measured.
U4a	Essential monitoring variables	**M**	Intensive monitoring of all of the performance indicators identified in this plan associated with every restoration site or project in the CRE&P would be prohibitively expensive. Such monitoring is not required for the satisfactory evaluation of trends and effectiveness provided that a strategic plan to prioritize monitoring intensity at sites throughout the CRE&P is developed.
U4b	Monitoring data transferability	**M**	Ditto.
U5	Cumulative restoration effects	**H**	This should demonstrate an overall impact(s) of the restoration program on the CRE ecosystem.

7.2 Program-Level Assessment

Individual projects must be implemented in the context of an overall EP-RME Program. This section examines four key elements of a successful RME program: 1) monitoring oversight, 2) data management and dissemination, 3) adaptive management and program evaluation, and 4) funding. This subject matter is consistent with recommendations in the Estuary Partnership's Monitoring Strategy (Estuary Partnership 1999) and RPA actions for the CRE&P in the BiOp (NMFS 2000).

7.2.1 Monitoring Oversight

The EP-RME projects (Table 7) are essentially a collection of somewhat independent efforts. Monitoring oversight is critical to develop an efficient and useful monitoring effort (Estuary Partnership 1999). At this time, monitoring oversight is provided by the funding agencies through their respective project review and coordination processes. The EP-RME Program, however, will require a dedicated and funded monitoring oversight entity, yet to be determined. At a minimum, the Policy Group for basin-wide RME should review and approve the EP-RME effort. The Action Agencies will continue to develop and coordinate the EP-RME effort.

7.2.2 Data Management and Dissemination

Besides monitoring oversight, a successful EP-RME Program must include data management and dissemination. This function is currently performed to various degrees at the project level. The EP-RME projects must feed data to a central data location. The data management approach proposed in the basin-wide RME plan would be appropriate. The EP-RME program supports the basin-wide data management effort including (from the Data Management RME Plan) plans to 1) develop a RME information system architecture, 2) use existing data centers where appropriate, 3) develop a cost-sharing approach, and 4) promote free-exchange of information.

[[INSERT – EP-RME data management requirements including data attributes, collection protocols, methods, standards, users, reporting requirements, etc.]]

Data must be analyzed and synthesized to produce information useful to decision-makers. Although analysis at the project-level is critical, the EP-RME program will require a comprehensive treatment of the data. Indeed, some projects, such as habitat mapping, cover the study area as a whole. No single entity is presently responsible for EP-RME data management and dissemination. Furthermore, the entity managing EP-RME data is a likely candidate to write annual reports for EP-RME. Annual reporting will be a key mechanism for data dissemination. In general, the EP-RME data team will have to understand the information needs of the decision-makers responsible for adaptive management and program evaluation.

7.2.3 Adaptive Management and Program Evaluation

Adaptive management means adjusting program objectives and methodologies based on new information. As such, it will bring the EP-RME program full-circle from the initial establishment of goals and objectives to implementation to data dissemination to program evaluation. As Noon (2003) stated, monitoring programs "…*must be constantly revisited and revised as scientific knowledge is acquired….*" Procedures should be established that link decision-makers to EP-RME monitoring overseers and data managers. Adaptive management for the basin-wide RME plan is explained in the RME Plan 2003. EP-RME adaptive management protocols will be consistent with those for basin-wide RME.

7.2.4 Funding

The purpose of this section is to briefly describe potential sources of funding for EP-RME and leveraging of these resources. Most EP-RME projects are funded from federal sources, such as the BPA, the COE, the EPA, and the USGS. State and local funds also contribute to EP-RME. Of particular note, COE funding mechanisms often require a "local" match resulting in effective resource leveraging. Thus, coordination among interested parties is essential. The Action Agencies are pursuing new and improved coordination for EP-RME, such as FY2003 funding for the Estuary Partnership for environmental monitoring in the CRE.

The BPA and COE, as responsible action agencies for implementation of the BiOp in the CRE&P, will fund some EP-RME projects, but not all. Certain EP-RME elements, such as water quality monitoring, are also objectives in other programs and are best funded from elsewhere. The Action Agencies intend to work with these other funding sources to develop a comprehensive EP-RME program.

7.3 Recommendations

Recommendations are provided at the project and program levels. The section closes with a recommended timeline for completion of the EP-RME plan and subsequent implementation.

7.3.1 Project Recommendations

In additions to the recommendations in Table 13, all ongoing and newly funded projects identified in Table 7 should be continued. These projects help meet the goals and objectives of the plan by providing data for status monitoring, action effectiveness research, and uncertainties research, as shown in Tables 8 and 9.

The Tributary RME plan includes pilot monitoring sites in the Wenatchee and John Day subbasins. The Action Agencies might consider another pilot monitoring site in the estuary as part of EP-RME. This would extend the RME concept of a regionally coordinated, programmatic approach to the CRE&P.

Although the coverage assessment dealt with the indicators designed to address EP-RME objectives, there is still a need for a project or process specifically designed to provide EP-RME program oversight, data management and dissemination, communication with regional RME, and linkage to the adaptive management process. In addition, a project or process needs to be initiated that produces an annual EP-RME report where synopses of results from all relevant work would be reported.

Table 13. Recommendations by indicator (Table 2) addressing needs for status monitoring, action effectiveness research, and uncertainties research.

Indicator	Category	Recommendation	Projects	Expected Outcome
Habitat inventory	SM	Expand CASI, inventory dikes, tidegates, culverts.	P1, P7	Detailed vegetation cover and feature maps
River inflow	SM	None	--	--
Plume conditions	SM, UR	Develop and prioritize parameters to characterize plume conditions	P2	Routine, annual characterization of plume conditions
Connectivity	SM, AER	Perform connectivity analysis Produce connectivity "map"	P8, P16	Detailed examination of connectivity Resolution of U3
Life history diversity	SM, AER, UR	Establish causal mechanism relating habitat structure and function to juvenile survival and relate to habitat rest. strategies.	P4, P8, P9, P19	Resolution of U3
Usage	SM, AER, UR	Develop habitat monitoring protocols and implement specially designed pilot studies, in coordination with ongoing mon. Monitor in the tidal fw reach	P8, P16	Improved habitat monitoring Resolution of U3
Growth	SM, AER, UR	Establish causal mechanism relating habitat structure and function to juvenile growth and relate to habitat rest. strategies	P4, P8, P9, P19	Resolution of U3
Fish distribution	SM, AER, UR	Coordinate monitoring efforts, assess the comprehensiveness of the sampling, and revise as nec. Determine habitats, pathways, residence times fir juvenile salmonids, especially subyearlings	P4, P7, P8, P9, P19, P21, P22	Comprehensive monitoring program of fish distribution
Survival	SM, AER, UR	Develop new tagging and detection methodologies	P18,P21	Fundamental data on survival thru CRE&P
Predator control	SM	Report relative success of tern relocation, pikeminnow removal	N/a	Evaluation of predator control

Indicator	Category	Recommendation	Projects	Expected Outcome
Water quality	SM	Coordinate the many projects	P5,P10,P12	Trend in WQ
Physical condition	SM, AER	Collect more subsurface data to aid restoration	P8, P16	Better information
Invasive species	SM, AER	Expand program	P11	Evaluation and treatment recomm.

7.3.2 Program Recommendations

The following recommendations are for the EP-RME *program*.

- Establish performance standards.
- Develop EP-RME data specifications.
- Establish an EP-RME monitoring oversight group.
- Coordinate with other basin-wide RME groups, the Estuary Partnership, other federal monitoring programs, and state and local monitoring efforts.
- Write annual EP-RME summary reports.
- Provide the annual reports to fisheries managers and other decision-makers.

7.3.3 Timeline

A proposed timeline for EP-RME has the final plan due on January 31, 2004 with a revised draft of the plan due on December 15, 2003 (Table 14). This schedule will synchronize the EP-RME effort with the overall RME process. EOS activities continue throughout FY04. EP-RME implementation is scheduled to begin in January 2004. The recipients of project funds will conduct EP-RME; however, a program oversight and coordination body has not yet been funded. This timeline is subject to approval by the Action Agencies and NOAA Fisheries.

Table 14. Timeline for EP-RME and Estuary/Ocean RME Subgroup (EOS) Activities in FY04.

	2003			2004								
Activity	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Review 9/30 draft												
Data Methods												
Sampling Design												
Perform. Targets												
Conceptual Model												
EOS Facilitation												
Basin-wide RME												
Reporting												
Draft Plans			*									
Final Plan				*								
Implementation												

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APPENDIX A: BiOp RPA Actions Related To the CRE&P

No.	Topic	Description	Lead RME Subgroup
158	Estuary Program Action Plan	Develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS system on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.	Estuary/ ocean
159	Estuary Habitat Restoration Plan	Develop a plan addressing the habitat needs of salmon and steelhead in the estuary.	Estuary/ ocean
160	Estuary Habitat Restoration Program	Develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the Columbia River.	Estuary/ ocean
161	Estuary RME Program	Develop a monitoring and research program to address the estuary objectives of this biological opinion.	Estuary/ ocean
162	Conceptual Ecosystem Model	Develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response.	Estuary/ ocean
185	Delayed Mortality Calculation	Define juvenile migrant survival for both transported and non-transported migrants and adult returns for both groups and compare the SARs of transported and non-transported fish to calculate the differential delayed mortality (D), if any, of transported fish.	Hydro
186	Delayed Mortality Expression	Compare the behavior and survival of transported and downstream migrants to determine whether causes of D can be identified for the reach between Bonneville Dam and the mouth of the Columbia River.	Hydro
187	Delayed Mortality and Ocean Entry	Evaluate relationships between ocean entry timing and SARs for transported and downstream migrants.	Hydro
193	New Tagging Systems	Develop new fish detection and tagging techniques.	Hydro
194	CRE&P Physical Model	Develop a physical model of the Lower Columbia River and plume.	Estuary/ ocean
195	Mortality Below BON	Investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.	Hydro
196	Salmon Usage of the Estuary	Develop an understanding of juvenile and adult salmon use of the Columbia River estuary.	Estuary/ ocean
197	Salmon Usage of the Plume	Develop an understanding of juvenile and adult salmon use of the Columbia River plume.	Estuary/ ocean

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APPENDIX B: Estuary Partnership's Monitoring Strategy

The Estuary Partnership's monitoring and evaluation strategies are shown in the table below. Specific BiOp-related RME efforts in the estuary/ocean arena will be coordinated with this broad, ongoing effort.

	Monitoring Oversight	Data Management	Conventional Pollutants	Toxic Contaminants	Habitat Monitoring	Exotic Species	Primary Productivity, Food Web
Phase One	♦set up coordination structure and monitoring committee, ♦develop interagency agreements and contracts, process to identify and allocate resources, ♦begin discussions on expansion of existing programs	♦locate all existing data, ♦improve access to data, ♦heighten public awareness	♦continue existing ambient programs for temp., TDG, bacteria, DO, pH, SS, TOC, C, nutrients, ♦track TMDLs for temp and TDS, ♦explore increasing scope and number of ambient sites, ♦begin discussions on consistent bacteria standards,	♦work w/USGS to redesign NASQAN to include toxics, ♦explore expanding existing ambient programs to include toxics, ♦establish baseline sampling network for toxics in sediments, ♦ develop random network for monitoring toxics in fish tissue, ♦begin discussions on discharge monitoring stations,	♦conduct workshop on measuring biological integrity, ♦develop agreements to share habitat data with all parties, ♦ develop habitat monitoring procedures, ♦contract for special study to survey existing habitat metadata,	♦develop agreements with all involved entities to share data and develop comparable procedures for monitoring exotic species, ♦evaluate existing information on exotic species to begin developing strategy for monitoring	♦explore expanding existing ambient monitoring programs to include productivity parameters DO, pH, TOC, nutrients, chlorophyll a, and BOD, ♦work with monitoring partners to begin development of index of biotic integrity for macroinvertebrates
Phase Two	♦continue oversight, ♦expand ambient programs, ♦expand special projects, ♦implement phase two components, implement phase two components, ♦ensure information reaching public, ♦add extra staff as needed	♦agreements on consistent monitoring protocol and procedures and data management standards, ♦ develop strategies for linking databases, ♦all data on STORET X, ♦ track development of other relevant data	♦expand existing ambient monitoring for other parameters and more sites, ♦ conduct synoptic study of temp in mouths of tributaries, ♦further define temp TMDL, ♦facilitate adoption of consistent bacteria standard, ♦work with USACE for QA/QC for TDG	♦expand existing sites to include toxics, ♦implement sampling for toxics in sediment and fish tissue, ♦contract for special study to analyze existing data, ♦develop sampling design and conduct reconnaissance sampling for toxics in water and suspended sediments, ♦contract for special study on hot spots, ♦establish discharge monitoring stations, ♦coordinate on radionuclide monitoring	♦complete analysis of metadata, ♦begin development of habitat monitoring scheme, ♦conduct second habitat monitoring workshop, ♦contract to conduct remote sensing, ♦contract to begin habitat monitoring ♦contract for aerial photography or high-resolution video multiple spectral scanning to characterize habitat,	♦complete review of existing data and finalize monitoring strategy, ♦implement sampling program aimed at species not currently being sampled, ♦contract to evaluate impacts of introduced species, ♦ develop strategy for monitoring introduction, ♦create educational program	♦expand existing sites to include productivity parameters, ♦ develop agreements with monitoring partners to incorporate IBI into sediment sampling for toxics, ♦contract for special study of suspended particulate mater, nutrients, and primary production including interactions with macrioinvertebrates,

	Monitoring Oversight	Data Management	Conventional Pollutants	Toxic Contaminants	Habitat Monitoring	Exotic Species	Primary Productivity, Food Web
Phase Three	♦continue oversight, implement phase three monitoring components ♦begin developing five year monitoring assessment report	♦implement short term approach to managing data using Estuary Program homepage to link a networked system of databases, ♦work with DEQ, Ecology and EPA to analyze data and develop reports	♦continue expanded ambient monitoring, implement TMDL management actions for temp and TDG, ♦ contract to conduct bacterial survey at selected beaches, ♦ conduct survey of water contract recreationists, ♦conduct evaluation of data and status report	♦evaluate results and adjust sediment toxic monitoring, ♦evaluate fish tissue study and conduct statistical analysis to determine future direction, ♦ evaluate results of reconnaissance sampling and implement long term program to track trends, ♦establish continuous turbidity sampling at selected sites, ♦contract for health study of human health risks associated with consumption of contaminated organisms, ♦develop guidance on management of contaminated non-dredge sediments.	♦contract for system wide bathymetry, ♦contract for analysis of habitat metadata to reconstruct historical landscape patterns, ♦begin assessment of overall habitat monitoring scheme	♦implement program to monitor mechanisms of introduction, ♦develop agreements to implement ongoing program to assess impacts of introduced species, ♦ continue and expand educational efforts,	♦assess results of special study on primary production and food webs to determine if useful way to measure biological integrity, ♦develop agreements to implement long term monitoring of productivity depending on assessment, ♦complete survey of metadata to assess historic and current sampling plans, ♦conduct an assessment of food webs from benthic invertebrates through fish, ♦develop a model of primary production
Phase Four	♦continue oversight, ♦implement any remaining monitoring components, ♦seek resources for and implement recommendations from 5 year monitoring assessment report	♦seek resources to implement the data recommendations from the 5 year report to possibly include totally interactive data management system	♦continue existing ambient programs ♦ implement permanent program for monitoring conventional pollutants based on recommendations of 5 year report	♦contract for study to identify trends in sediments through core sampling and analysis, ♦use cores to determine the effect of extreme hydrologic events, ♦contract to evaluate the impact of native versus hatchery fish on tissue contaminant data, ♦evaluate recomm. from 5 year report and adjust program	♦continue coordination of interagency habitat monitoring and assessment of data, ♦evaluate results of 5 year report and adjust existing habitat monitoring program, ♦develop and implement new strategies	♦evaluate results of 5 year report and adjust existing nonindigenous species monitoring efforts based on finding of the report	♦contract for reconstruction of history of water quality in estuary and behind selected reservoirs using diatoms in sediments, ♦contract for a reconstruction of organic matter sources for food webs using multiple stable isotopes, ♦evaluate recommendations of 5 year report and adjust monitoring efforts