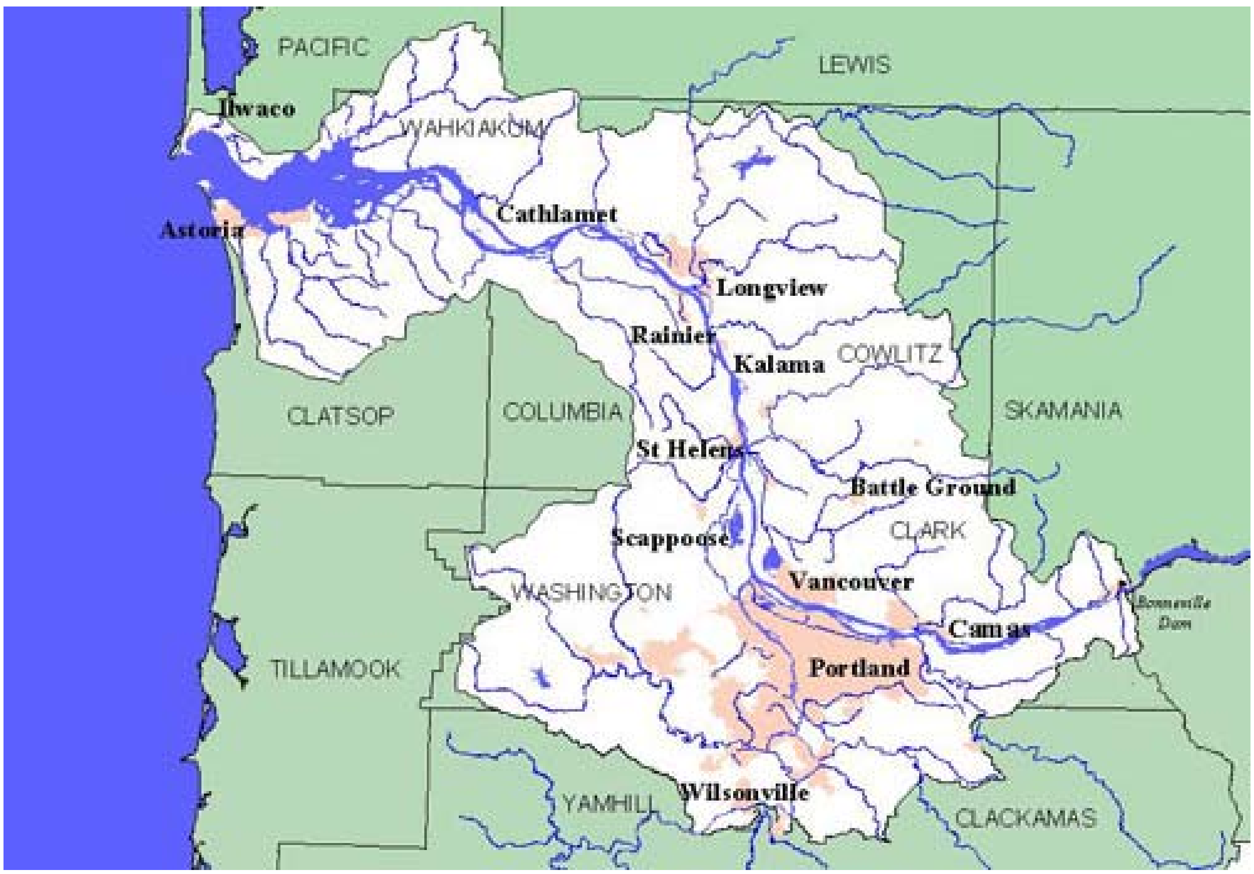
LOWER COLUMBIA RIVER AND ESTUARY RESEARCH NEEDS IDENTIFICATION WORKSHOP PROCEEDINGS

March 24 - 25, 2003 *Portland, Oregon*



US Army Corps of Engineers

LOWER COLUMBIA RIVER ESTUARY PARTNERSHIP

FINAL

2003 Lower Columbia River and Estuary Research Needs Identification Workshop Proceedings

March 24 and 25, 2003
Portland, Oregon

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TABLES

ACKNOWLEDGMENTS

This workshop was organized by the following steering committee members: Blaine Ebberts (U.S. Army Corps of Engineers, Portland District); Bruce Sutherland (Lower Columbia River Estuary Partnership); Cat Black (Columbia River Inter-tribal Fish Commission); Gary Johnson (Pacific Northwest National Lab); Rick Mischaga (Port of Portland); David Moryc (American Rivers); Cathy Tortorici (NOAA Fisheries); and Allan Whiting (Columbia River Estuary Taskforce). Kathi Ruiz (Pacific Northwest National Laboratory) coordinated workshop logistics.

The insightful discussion and comments from the workshop participants helped to make this workshop a success. The workshop benefited particularly from the input of a panel comprised of experts familiar with the Columbia River Estuary and estuarine research in general. The experts represented a range of physical and biological disciplines, and included: Antonio Baptista (Oregon Health and Science University), Earl Dawley (consulting biologist), Steve Ellis (MCS Environmental), Jim Good (Oregon State University), Brian Riddell (Columbia River Independent Science Review Panel), and Ron Thom (Pacific Northwest National Laboratory).

Paul DeMorgan, Michaela Ledesma, and Kathy Schulz of Resolve, Inc., facilitated the workshop, breakout sessions, and panel discussions.

Paul DeVries, Dudley Reiser, Ron Campbell, and Catherine Morello of R2 Resource Consultants, Inc. helped with moderating the panel discussions and produced this report, which was prepared from workshop notes of steering committee members, workshop participants, and Resolve and R2 staff. We thank Blaine Ebberts, Gary Johnson, Cathy Totorici, Bruce Sutherland, and Earl Dawley for their helpful review comments of a working draft.

EXECUTIVE SUMMARY

A workshop was held on March 24 and 25, 2003 in Portland Oregon at the World Trade Center to discuss research status and needs for the Columbia River Estuary (CRE). The objectives of the workshop included:

- Review the basis for USACE involvement in the CRE;
- Review past and ongoing research being conducted in the CRE;
- Identify data gaps and key research needs for future studies; and
- Prioritize as much as possible those research needs.

This workshop included collaboration and sharing of past and present research information to critically define information needs, objectives and gaps, and to solicit input for future decision making regarding restoring the CRE ecosystem. These goals were to be met through plenary presentations, panel discussions and facilitated workgroup breakout sessions. Poster presentations were also on display during the workshop.

A large number of themes were discussed at the workshop, including: Developing a conceptual framework for ecosystem restoration in the CRE; Monitoring and selecting meaningful metrics and parameters; Identifying and prioritizing habitat creation and restoration options; Endpoint (target) definition; Mining under-used, older data; Information access and integration; Comparing historic vs. present habitat conditions; Hydrodynamic model data collection; Sediment transport and fate; Hydrograph changes; Linking physical processes with biological systems; Salmonid abundance, habitat use, migration, and timing; Stock identification, hatchery influences and phenotypic expression; Wetlands function; Nutrients, detritus, and primary productivity; Food web dynamics; Tributary conditions and opportunities for off-site mitigation; Toxic contaminants and geochemistry; Invasive species; Risks associated with restoring 10,000 acres in the CRE; and other miscellaneous topics.

The workshop did not end with construction of a list of priority research needs. However, the substance of discussions was noted, and that information has been compiled and synthesized in this document. Highest priority research avenues have been inferred from the workshop discussions in Section 4 of this document, which provides the US Army Corps of Engineers with the starting framework for funding research in the CRE that maximizes restoration potential and addresses key action items specified in the Federal Columbia River Power System Biological Opinion of 2000.

1. INTRODUCTION

1.1 BACKGROUND

The Columbia River estuary (CRE) presents an important physical and biological interface for salmon and trout as they transition between their ocean and freshwater life stages. Juvenile salmon utilize various areas in the estuary to rear and undergo osmotic transition. Rearing locations, seasonal timing, residence timing, and migration pathways differ between species and even between stocks of the same species. The CRE also provides important rearing habitat for other animal species of marine origin, and year-round habitat for species that have evolved to live solely within an estuarine environment. The CRE has undergone tremendous change as a result of settlement and development, with myriad effects to its physical character and biological resources. Physical characteristics such as depth, velocity, salinity, temperature, and turbidity vary dynamically in time and space within the CRE, which in turns presents a highly variable environment that organisms have adapted to. The wide variety of environmental changes that have occurred have substantially affected habitat availability, habitat quality, species composition, and other biological attributes of the estuarine ecosystem. The complexity of the physical and biological processes and interactions within the CRE system has contributed to less than complete understanding of the challenges and opportunities faced by aquatic organisms, including specifically salmon and trout.

A number of efforts have occurred over the past 20 years and more to obtain a better understanding of the CRE ecosystem and the factors driving it. These efforts have culminated most recently in the development of a comprehensive state-of-the-knowledge description of the ecological underpinnings of the estuary, through publication of "Salmon at River's End" (SARE; Bottom et al. 2001). That document reviewed the historical development of the CRE relative to changes in salmon populations, evaluated alternative conceptual frameworks for evaluating estuarine habitat conditions, assessed the effects of climate and the hydropower system on river flow and sediment transport, tested habitat availability predictions of the most detailed and up-to-date hydrodynamic model of the estuary, evaluated biological and bioenergetic factors influencing salmonid rearing capacity, and evaluated population characteristics of juvenile salmon at various periods during the development of the CRE and Columbia River upstream (Bottom et al. 2001).

Other documents that have provided up-to-date synopses of the status of salmon in the Columbia River and its estuary include the 2000 Federal Columbia River Power System Biological Opinion (FCRPS BO; National Marine Fisheries Service 2000), and the recent Columbia River Channel Improvement Project Supplemental Integrated Feasibility Report and Environmental

Impact Statement (CRCIP SIFR/EIS), prepared by the Portland District of the U.S. Army Corps of Engineers (USACE 2002). These reports provide descriptions of what we know about the capacity of the estuary to support salmon in terms of population size and health, and the factors that may influence that capacity. It is generally agreed in all three documents that capacity has been reduced, and that appropriate restoration measures may be instrumental to recovering listed salmon and trout stocks. However, because of the complexity of the problem, there is much that remains to be resolved regarding where research and restoration efforts should be focused first. Moreover, there are at least two important regulatory drivers requiring research and action in the near term: the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA). The FCRPS BO and the CRCIP SIFR/EIS provide guidance regarding important research needs and some of the types of projects that may be implemented in the CRE to recover depressed salmon and trout populations. The BO in particular identified a number of action items in its Reasonable and Prudent Alternative that specifically addressed estuary research, conservation, and restoration activities supporting the survival and recovery of ESA-listed salmonids (Table 1).

These action items provide a regulatory framework for research and restoration in the CRE, but do not provide the actual road map. In light of this, it became clear to the USACE and its partners in the Lower Columbia River Estuary Partnership (LCREP) that addressing the complex problem of restoration in the CRE required a solid understanding of the state-of-the-knowledge regarding salmon usage of the CRE. Key to this would be to identify what we do not understand well but really should, i.e., identify research needs. Therefore, a workshop was convened to bring together a large number of persons with experience working both specifically in the CRE and other estuarine systems. That workshop is the subject of this document.

1.2 THE 2003 COLUMBIA RIVER ESTUARY WORKSHOP: OBJECTIVES

The Portland District of the USACE and the LCREP hosted the workshop to address research needs and priorities for the CRE. The two-day workshop was held on 24-25 March 2003, at the World Trade Center in Portland Oregon. The objectives of the workshop included:

- Review the basis for USACE involvement in the CRE;
- Review past and ongoing research being conducted in the CRE;
- Identify data gaps and key research needs for future studies; and
- Prioritize as much as possible those research needs.

Table 1. CRE-related actions in the 2000 FCRPS BO.

158	During 2001, the Corps and Bonneville Power Administration (BPA) shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS system on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.
159	BPA and the Corps, working with LCREP and NOAA Fisheries, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.
160	The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the Columbia River.
161	Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NOAA Fisheries and closely coordinated with the LCREP monitoring and research efforts to address the estuary objectives of this Biological Opinion.
162	During 2000, BPA, working with NOAA Fisheries, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response.
163	The Action Agencies and NOAA Fisheries, in conjunction with the Habitat Coordination Team, will develop a compliance monitoring program for inclusion in the 1- and 5-year plans.
194	The Action Agencies and NOAA Fisheries shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the lower Columbia River and plume.
195	The Action Agencies shall investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.
196	The Action Agencies and NOAA Fisheries shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary.
197	The Action Agencies and NOAA Fisheries shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.

This workshop included collaboration and sharing of past and present research information to critically define information needs, objectives and gaps, and to solicit input for future decision making regarding restoring the CRE ecosystem. These goals were to be met through plenary presentations, panel discussions and facilitated workgroup breakout sessions. Poster presentations were also on display during the workshop. There were approximately 100 participants the first day, and 50 the second. Participants represented a wide variety of public and private interests.

This workshop built on two related, previous workshops, including: the Biological Integrity Workshop held in Sandy, Oregon in May 1999; and the Lower Columbia River and Estuary Habitat Conservation and Restoration Workshop, held in Astoria, Oregon in June 2001. Copies of the proceedings from those workshops are available from the LCREP and USACE.

1.3 DOCUMENT OUTLINE

This document presents and summarizes important information, findings and conclusions shared during the course of the two-day workshop, which consisted of formal presentations, panel discussions, and two organized breakout sessions. This document has been organized accordingly to first summarize the formal presentations made on the first day of the workshop, and then the discussions that ensued from the panel and break-out sessions. The document is organized into five main parts that include, in addition to this section:

- Section 2: SUMMARY OF PRESENTATIONS REVIEWING THE STATUS OF RESEARCH IN THE COLUMBIA RIVER ESTUARY (summarizes important information from the individual presentations);
- Section 3: PANEL AND WORKGROUP DISCUSSIONS, AND WORKSHOP THEMES (summarizes the panel and workgroup session discussions and conclusions);
- Section 4: CONCLUSIONS (provides preliminary recommendations relative to research needs and priorities as identified during the workshop).
- Section 5: REFERENCES

This document also includes six appendices (A through F) providing supporting background information, including the workshop agenda, list of attendees, presentation abstracts, flipchart notes from the breakout sessions, and poster titles.

2. SUMMARY OF PRESENTATIONS REVIEWING THE STATUS OF RESEARCH IN THE COLUMBIA RIVER ESTUARY

The following presentations were given on the first day of the workshop. The presentations were given to provide relevant background and context for the workshop and summarize recent research findings. The first three presentations provided the context for the workshop, followed by a number of invited speakers who presented overviews of their research, and what they thought were critical questions needing further evaluation.

Presentation 1: Workshop Background And Expectations

Bob Willis, U.S. Army Corps of Engineers (USACE), Portland District.

The purpose of this presentation was to promote outcomes and expectations for the workshop. It is the hope of the USACE that this workshop will lead to further collaboration in developing ecosystem restoration actions for the lower Columbia River, and that this workshop will also lead to clearly defining critical research needs that will positively direct effective ecosystem restoration actions. In light of funding limitations, collaboration is crucial for critically defining and realizing research needs and objectives. A consistent and well thought out direction for research planning is needed.

The presentation focused on three main topics that must be considered in the course of planning USACE-sponsored research in the CRE:

1. The 2000 Federal Columbia River Power System Biological Opinion (FCRPS BO) requirements, which is presently the driver for research and restoration activities in the CRE;
2. USACE Authorities; and
3. Processes through which research activity needs and funding are determined for the Columbia River system.

Of the numerous Action Items listed under the Reasonable and Prudent Alternative (RPA) in the FCRPS BO, there are two that are of greatest importance to this workshop, because they are most directly relevant to Corps authorities and programs concerning restoration work in the CRE:

RPA Action Item 160 – The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over ten years.

- The USACE needs to know what the attributes of that habitat are and which are most important to address, and what measures are most cost effective.

RPA Action Item 161 – The Corps and BPA are to develop a research and monitoring program.

- This workshop was conceived to help the USACE begin conceptualizing and developing the plan.

Work to meet these RPA's is underway and includes basic applied research. Collaboration is occurring, as evidenced by the mix of people and organizations supporting this workshop. Critical questions include: Are these the correct studies and are there better, more cost efficient ways to answer needed questions leading to habitat development?

For background, the Corps and BPA have funded several projects, including Salmon at River's End (the role of the estuary in the decline and recovery of Columbia River salmon) and the 2001 Lower Columbia River and Estuary Habitat Conservation and Restoration Workshop. SARE was funded by BPA to address primarily the following four questions concerning salmon in the estuary:

1. What habitat and processes support native salmon populations during the estuary phase of their life history?
2. Have changes to the estuary had a significant role in salmon decline?
3. What have been the impacts of flow regulation on the hydrology, habitat, and biological interaction in the estuary ecosystem?
4. What estuary conditions are necessary to maintain diversity of salmonids in the Columbia River Basin?

The 2001 workshop included plenary presentations, panel discussions and facilitated workgroup sessions, with approximately 100 attendees interested in estuarine restoration. A number of potential restorations sites were identified and criteria developed to help in the prioritization of these sites. Subsequently, specific considerations were developed to address estuarine habitat restoration criteria, working through the Lower Columbia Estuary Program Science Workgroup.

Beginning in 2001, under the Columbia River Fish Mitigation project, specific research and monitoring activities were initiated, including:

1. Establishing current and historical linkages between juvenile salmon and estuarine habitats. This project included multiple objectives, including determining the temporal relationship between tidally influenced habitats (lower river and estuary) and the presence/absence, abundance, and benefit to juvenile salmon, with an emphasis on

shallow water areas, dendritic channels, backsloughs, and main channel margins in the Columbia river;

2. A study to estimate salmonid survival and habitat use throughout the Columbia River estuary with acoustic tags, which involved supporting research and development related to downsizing acoustic tags;
3. Evaluating the relationships between salmonid survival, migration timing and physical environment, including adult returns, which has involved the rearing of fall Chinook juveniles and differential timed releases into the estuary; and
4. An inventory of floodplain habitat and cover types in the Lower Columbia River and estuary, 2002.

Other research associated with the juvenile fish transportation program, Caspian tern research, and other programs are also underway.

The following Corps Authorities are relevant to restoration work in the CRE:

1. Section 1135 of WRDA 1986 Project Modifications to improve the environment; restore degraded ecosystems that resulted from Corps projects. (75% Federal / 25% non-Federal cost share, $5 million per project maximum Federal expenditure).
2. Section 206 of WRDA 1996 Restore degraded aquatic ecosystem to a more nature condition. (65% Federal / 35% non-Federal cost share, $5 million per project maximum Federal expenditure).
3. Section 536 of WRDA 2000 Ecosystem restoration in the Columbia River and Tillamook Bay estuaries. (65% Federal / 35% non-Federal cost share, Federal lands 100% Federal share, $30 million total for the two estuaries).
4. Planning assistance to states and tribes, cost-shared study of water- resource-related problems. (50% Federal / 50% non-Federal cost share, limited to $500K per state/tribe/year, studies only, no implementation).
5. Lower Columbia River Ecosystem Restoration General Investigation, plan for ecosystem restoration, potential application for large projects, land acquisition, investigations, requires cost sharing.
6. Section 582 expansion-estuarine research; Columbia River Fish Mitigation Project (CRFM), congressionally funded, for upstream projects, SCT prioritization.

Regarding research funding mechanisms, Willis gave an overview of the Anadromous Fish Evaluation Program (AFEP) and important dates for proposal submittal and review. The main purpose of the AFEP is to produce scientific information to assist the Corps in making engineering, design, and operations decisions for the eight mainstem Columbia and Snake River projects to provide safe, efficient passage through the mainstem migration corridor. The AFEP process timeline begins in February or May by outlining research needs, with work beginning the following February. Generally, most restoration actions require cost sharing and an agreement to provide operation and maintenance. BPA/Northwest Power Planning and Conservation Council funds may be used for the cost sharing.

Interested parties were referred to the following individuals for specific information regarding proposing CRE restoration projects under USACE funding programs:

OVERALL PROGRAM

Bob Willis, Chief, Environmental Resources Branch, (503) 808-4760
Martin Hudson, Chief, Planning Branch, (503) 808-4703

ESTUARY PROGRAM AND SECTION 536

Taunja Berquam, (503) 808-4757

CONTINUING AUTHORITIES PROGRAM

Doug Putman, (503) 808-4757

AFEP PROGRAM

Rock Peters, (503) 808-4777
Blaine Ebberts, (503) 808-4763

In conclusion, Willis summarized three important aspects to estuary restoration:

- Collaboration – needed for project efficiency;
- Prioritization – needed to focus research on what is the most important; and
- Partnership – needed to provide cost sharing opportunities in conducting the necessary studies.

Presentation 2: Research Gaps Based On Past Work And Current Work

Bruce Sutherland, Lower Columbia River Estuary Partnership

Bruce Sutherland briefly reviewed the three workshops involving the LCREP, including the 1999 Biological Integrity Workshop, the 2001 Habitat Conservation and Restoration Workshop, and the present (2003) Research Needs Identification Workshop.

The goal of the 1999 workshop was to determine how to measure biological integrity. The workshop identified the need for comprehensive habitat maps. As a result, an innovative mapping project was launched (currently being completed, with a demo available from the LCREP). This project produced highly detailed data layers and GIS maps of vegetative habitat for the lower 146 river miles of the Columbia. The maps and data layers will be useful for identifying juvenile salmonid estuary utilization and for developing restoration projects. These maps are also useful tools for analysis of current and historical habitat changes.

The 2001 workshop outlined six criteria for evaluating and prioritizing habitat conservation and restoration projects, and helped set the framework for establishing a comprehensive restoration program and future restoration work.

The present (2003) workshop will review the current knowledge base and identify research gaps that need to be filled and determine what else we need to know to effectively implement salmon recovery and ecosystem conservation and restoration.

B. Sutherland then reviewed past and present research and monitoring work of the LCREP. He briefly described the Bi-State Water Quality Study (1990 – 1996) funded by Oregon, Washington, and the private industry that led to the formation of the Lower Columbia River Estuary Partnership as part of the National Estuary Program. That study developed more than 50 technical reports forming the first comprehensive compendium of information on the health of the river from the mouth to Bonneville Dam. Based on those reports, the following problem areas were identified:

- Toxic contaminants
- Habitat loss or modification
- Water quality problems that affect beneficial uses
- Paucity of basic data
- Overall declines in fish and wildlife health
- Need for evaluation of river condition over time

To address those issues, the LCREP established an expert work group led by USGS that spent two years developing a long term monitoring plan. The group ultimately developed a comparative approach to ecosystem monitoring that included:

- An Aquatic Ecosystem Monitoring Strategy, and
- A data management strategy

The Aquatic Ecosystem Monitoring Strategy envisions the establishment of an Interagency Management Team which would oversee the following six basic components:

1. Toxics/contaminants monitoring in sediments, tissues, and the water column.
2. Habitat monitoring for bathymetry, bottom composition, channel configuration, disturbed areas, and vegetative state as well as wetlands mapping and assessment.
3. Exotic Species monitoring to evaluate impacts, identify species composition, monitor introductions, track changes over time and develop educational programs.
4. Conventional pollutants monitoring for bacteria, sedimentation, dissolved oxygen, water temperature, nutrients, pH, and total dissolved gas.
5. Primary productivity, including benthic algae, chlorophyll a, fish, macroinvertebrates, and plankton.
6. Development of a data management system known as ERIC, the Ecosystem Restoration Information. That system would include the ability to develop customized reports, provide outreach to interested parties, have interactive web access, linked systems, and establish a standard data reporting and storage format.

Sutherland listed the following items as the priority information needs:

- Common data management system
- An index of biological integrity for macroinvertebrate
- Routine monitoring of productivity
- An understanding of the impact of invasive species
- Habitat monitoring protocols
- System-wide bathymetry
- Fish toxic contaminant exposure and uptakes
- Baseline toxic monitoring
- Expanded ambient monitoring

In conclusion, B. Sutherland posed the questions: How do we manage complexity of this system both biologically and politically and where are we in that process? He concluded that much remains to be done before we can fully understand and answer these questions.

Presentation 3: How Past Research Has Informed Decision-Making On Columbia River Estuary Restoration And Future Research Needs

Cathy Tortorici, NOAA Fisheries

Tortorici reaffirmed that the FCRPS BO (and associated RPA Action Items) is the driver of research in the CRE currently. There are three action agencies involved: Bonneville Power Administration, Corps of Engineers and Bureau of Reclamation. The Biological Opinion requires the action agencies to avoid jeopardy to 12 listed salmon and steelhead ESUs in the Columbia Basin. These ESUs exhibit a diverse range of adaptations, and include both ocean-type and stream-type life history strategies. The specific related RPA's are 158, 159, 160, 161, 162, 194, 196 and 197. These actions are all interrelated, not just for the estuary, but the habitat ecosystem as a whole.

Four primary data programs were identified as providing much of what we know about lower river habitats:

1. Columbia River data development program CREDDP study (1979-80) provided the first real estimates of fundamental processes and a broad perspective. Results indicate that substantial habitat loss and degradation occurred after the 1800's. Only 35% of the former area of marsh and swamp habitat was estimated to have remained in the estuary after 1980.
2. Historical habitat of the lower Columbia River (CREST 1995) early mapping products available for the lower river also indicate changes may be more modern, 1973-1983.
3. Floodplain habitat cover types (LCREP), including an assessment of marshes and sloughs
4. Salmon at River's End (Bottom et al. 2001)

Tortorici identified six elements of habitat restoration in the Columbia River Estuary (from SARE):

1. Estuary development history and salmon decline
2. Concentrated framework for evaluating estuarine habitat conditions
3. Changes in hydrologic conditions
4. Changes in habitat opportunity
5. Changes in habitat capacity
6. Changes in salmonid population structure, life history, growth, and estuarine residence.

We have simplified the ecosystem and life history patterns through habitat and flow modification and hatchery supplementation. A key assumption of the SARE report is that the resilience of Columbia River salmon to natural environmental variability is embodied in population and life history diversity, which maximizes the ability of populations to exploit estuarine rearing habitats.

Tortorici believes that we have a basic understanding of physical processes in the CRE system. We are currently faced with the question, what more do we need to know? The following gaps were identified in the knowledge base:

- How salmon life history strategies are currently, and were historically using the system (i.e., is the dependence on hatcheries resulting in simplified natural life histories with reduced variation?).
- What was there historically, and how has management effected changes?
- What is happening in the CRE in response to flow regulation?
- We have a basic understanding of the physical environment, but how does it connect to the biology?

Relating habitat opportunity, capacity and population structure to performance is difficult. Perhaps diversity is the key to relationship. Tortorici believes it is important to be collaborative to understand the best locations and methods for restoration. The following restoration needs were identified: protect and restore forested wetlands and tidal habitats, and expand phenotypic diversity of salmon life histories. A fundamental research approach involves reconstructing changes in river flows and habitat and trying to interpret those changes.

Lastly, there are several critical monitoring needs, including long term measures of:

- Variation in juvenile salmonid diversity,
- Habitat use, and performance.

In addition, it is important to consider how to disseminate monitoring data and information. Tortorici concluded with a suggested programmatic approach for determining actions needed in the lower river, estuary, and ocean.

Presentation 4: Modeling Circulation In The Lower Columbia River: Status And Vision

Antonio Baptista, Oregon Health and Science University / OGI School of Science and Engineering (OHSU/OGI)

Baptista covered four topics in his presentation: Columbia River circulation (described as a complex tale with regional implications), the CORIE observation forecast modeling system, other research modeling efforts, and future modeling tools.

Baptista described how the Columbia River estuary is a dynamic and highly diverse system with many regimes and strong gradients. External forcings acting on this system are highly variable, complex and connected. Example forcings include: discharges, tides, winds, ocean influences, river salinity influences, atmospheric pressure and short waves. Baptista indicates that the Columbia River estuary and plume are interconnected as well, and cannot be modeled in isolation. The river plume is extensive and may extend from British Columbia to California, depending on season or conditions. In addition, when modeling it is hard to separate anthropological impacts from natural impacts.

CORIE is the observation and forecast system that is currently being developed for the Lower Columbia River. It has four regions of interest: estuary, near plume, upriver and far field plume or coastal ocean. CORIE offers customized products including real time observations, interactive circulation database, observational data, daily forecasts, and modeling tools. Applications of the CORIE system are diverse and include search and rescue, oil spill cleanup, tracking of fish movements relative to tidal circulation, and quantifying habitat opportunity as defined by depth, velocity, salinity, and turbidity habitat suitability criteria. These applications involve ways of linking and integrating physical and biological aspects of the CRE system. Habitat opportunity evaluations also provide a means for comparing historic, present, and projected future habitat conditions to identify potential habitat bottlenecks and more effectively direct restoration efforts.

Other relevant models of the Columbia River mentioned by Baptista that can be evaluated with CORIE include:

- River Influences on Shelf Ecosystems (RISE) – Collaborative work between University of Washington (MacCready) and OGI/CORIE team.
- USACE/WES work on Columbia River Mouth, channel deepening, and small scale restoration project evaluation
- Foster Wheeler, Chinook River Restoration Efforts

- Columbia River temperature model (Yearsley)
- Port of Portland LOADMAX modeling

There are many future uses for modeling systems, such as CORIE. To help link physical and biological processes, Baptista states these models should not be isolated and their use should be integrated into decision making and modeling efforts in the Columbia River. Increased knowledge of past and present bathymetry is very important to future modeling and poses as one of the most significant data gaps in the context of hydrodynamic modeling of the CRE.

Presentation 5: A Unified View Of Research Needs For The Columbia River, Estuary And Plume

David A. Jay, Oregon Health and Science University / OGI School of Science and Engineering (OHSU/OGI)

Jay focused his discussion on three topics: research to date, biophysical problems to solve, and how best to solve them. Overall we need to understand the Columbia River system as an integrated whole, to deal with pressing management issues. Programs of current research include: NSF Columbia River plume biophysics study (RISE conceptual model and estuarine sediment trapping/export and transportation methods), BPA (estuary study, plume study, FCRPS impacts on juvenile salmon in 2004), NOAA-NESDIS plume remote sensing, and COE (analysis for changes in fluvial salmon habitat and suspended sediment supply).

Jay indicated there are three geographic regions where problems need to be addressed (in an integrated manner): river basin, tidal river, and estuary and river plume. He believed research on river basin hydrology is going well, but we still need to know much more concerning sediment supply and budget. The following is a list of some questions that he believes should be researched in this area:

- What is the sediment budget response to climate change, forestry and agriculture?
- What are the effects of dredging?
- What are the sources of fines and sand?
- How has reduced sediment supply impacted estuarine habitats and littoral processes?

Jay recommended that we model and monitor sediment and sand transport and bathymetric changes. We should make process measurements in river and estuary to further understand transport and ecosystem connections. Sediment and turbidity are vital resources that should be understood as a unified whole from source to plume. Geochemistry should also be addressed, e.g., nutrient supply and chemistry, iron as a limiting factor, and changes in organics with flow and season and their importance to the estuary and plume. Sediment and turbidity are vital resources.

Many data gaps were defined by Jay in the tidal river and estuary, including: effects of changes in topography, bedload materials, tidal and salinity regime; turbidity maximum; sediment budget; and processing of nutrients. What we don't know very well is how these changes constrain management of navigation, flows, and habitat restoration.

The river plume and coastal ocean are considered to be vital habitat for juvenile salmonids. The research gaps in this area of the basin are ill defined according to Jay. Remaining questions include:

- What role do nutrients play in productivity?
- How about flow management and climate change?
- What are salmon responses to tides?
- How do management practices conflict with a system approach to understanding and management?

To solve these issues, Jay indicated it would be beneficial to further understand system management through improved communication and involvement of other coastal ocean research institutions (e.g., University of Washington), and study current and historical research taking place in other systems (e.g. Colorado River). It would be useful to define flow scenarios that maximize estuary/plume salmonid habitat, based on knowledge of physical processes. In summary, he noted that the Columbia River estuary and coastal ocean function as a system that needs to be understood in an integrated way. An organized effort should be made to define and answer system-level questions. There is a need to involve a broader group of Pacific Northwest scientists, and learn from science/management of other systems. Jay noted the need to modify management practices interfering with understanding and managing the system in an integrated manner.

Presentation 6: Hydrodynamic And Hydrologic Feasibility Assessment-Chinook River Restoration Project

Tarang Khangaonkar, Tetra Tech / Foster Wheeler Environmental Corporation

Questions addressed by this project included:

- How will the Chinook River estuary respond to restoration?
- What will the salinity penetration be?
- What will be the extent/effects of that salinity penetration?
- Will proposed measures kill reed canary grass or other species?

A variety of alternatives were modeled, including keeping the existing leaky tidegates, and removing the tidegates and creating 28', 56', 104', and 200' breaches. Khangaonkar integrated output data from Baptista's model as input for this model. The conclusion of the hydrologic and hydrodynamic modeling was that restoration would be feasible with replacement of the tide gate by a 200 foot opening and construction of an internal levee inside the project area to protect selected private lands from tide- and storm-related flooding. The selected width in part reflected maximum velocity and fish swimming constraints in the opening during tide changes, and reducing scour potential in the vicinity of the opening.

Presentation 7: Assessing The Role Of The Columbia River Estuary In Growth And Survival Of Juvenile Salmon

John Ferguson (for Ed Casillas), Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service

An overall program focus for NOAA Fisheries is to determine the role of habitat in the CRE in the salmon life history cycle. Ferguson indicated that the research is intended to gather sufficient biological and physical information to provide a basis for making management decisions in the future, including determining how money should be spent. He listed four specific, current goals of the NOAA Fisheries salmon and estuary program:

1. Develop empirical basis for estuary role;
2. Identify habitat features at landscape scale that influence abundance, performance, diversity, and spatial structure;
3. Assess impact of natural variation and human disturbance; and
4. Develop tools to evaluate management action scenarios.

To achieve those goals, NOAA Fisheries is involved in five types of studies:

- Describe empirically the role of the CRE, including how the plume:
  - Affects juvenile salmon offshore dispersion, small changes in discharge alters dispersal at high flows
  - Seeds early ocean productivity (i.e. zooplankton prey)
  - Creates beneficial salmon habitat, refugia, transition zone, food concentration

- Identify habitat features at the landscape scale that influence salmonid abundance, diversity and spatial structure, recognizing that fish utilize similar habitats in different ways at different times, by evaluating:
  - Chinook densities in emergent marshes
  - Timing of ocean entry relative to hydropower system and influences on survival
  - Salmon distribution and life history at a landscape scale

- Develop new technologies, including:
  - Research and development of microacoustic tags for smaller juvenile chinook
  - Installing acoustic tag detection arrays to measure migration and habitat residence timing
  - GIS analysis of historic floodplain and habitat changes

- Assess impact of natural variation and human disturbance, including studies of:
  - Tern predation and PIT tag recovery at nesting colonies
  - Historic changes in shallow water habitat analysis
  - Heavy metal and organic (DDTs, PCBs, PAHs) pollutant contamination and toxicity to juvenile salmon

- Develop tools to evaluate management action scenarios, including ways of:
  - Integrating and evaluating natural and human impacts and modifications on the ability of salmon to access and benefit from estuarine habitat.
  - Developing linkages between the biological and physical environments using the CORIE model, to answer questions such as:
    - How fish use habitat

- What is important for recovery
- How to recover populations
- How to identify and meet restoration criteria

Ferguson closed with a slide identifying information needs and direction for the CRE. Monitoring and modeling are both necessary components for developing a restoration plan, and both rely on identifying suitable habitat metrics.

Presentation 8: NOAA Technical Recovery Team For The Willamette And Columbia Rivers

Tom Clooney, NOAA Fisheries

The Technical Recovery Teams (TRTs) provide basic, standardized information for establishing a technical basis for planning ("Phase 1"), and supporting the development of recovery actions ("Phase 2"). Two TRTs are presently relevant to the CRE: the Willamette and Lower Columbia TRT, and the Interior Basin TRT. Each TRT is unique in approach but all provide recommendations and insights. The TRTs provide input to recovery planning through the development of:

- Objective and measurable criteria for delisting;
- Site-specific management actions; and
- Estimates of time and cost required.

Initial tasks of the Technical Recovery Teams include:

1. Define Evolutionarily Significant Units (ESUs) and identify (meta)populations;
2. Develop population viability criteria for ESUs;
3. Develop monitoring and evaluation recommendations;
4. Evaluate ESU viability scenarios;
5. Develop fish productivity and habitat relations (lifecycle considerations); and
6. Determine limiting factors and factors of decline.

The first and second tasks have required reviewing previous research and data regarding salmon populations, and analyzing population structure. The TRT's have in the process solicited peer review prior to publication of their final report.

The monitoring and evaluation recommendations of the TRTs include parameters that should be monitored to determine population status and trend. TRT contributions also include determining which populations are most suitable for studies of hatchery fish spawning effectiveness in each ESU, and identifying (i) monitoring parameters important for recovery planning, and (ii) opportunities for action-specific monitoring aimed at determining fish population responses.

As the TRT identifies primary opportunities to improve survival for different life history types, it looks at estuarine habitat availability and utilization. Factors that have been considered in the CRE include habitat-specific growth rates and survival, changes in the food web that have occurred over time, effects of contaminants on growth and survival, and exposure to predation.

Ultimately, the TRTs evaluate opportunities in the CRE and lower mainstem Columbia River for survival improvements for the various listed ESUs. Questions having bearing include: How do habitat conditions relate to populations and life history patterns, and how have habitat conditions changed with respect to life history types? One avenue of continued interest concerns evaluating future climate and environmental scenarios, which could involve holding a workshop.

Potential phase two TRT roles include: Quantitatively evaluate different combinations of actions to ensure they will lead to recovery, assess the relative certainty of achieving recovery goals given alternative sets of actions, and assess how different temporal trajectories for recovery affect the probability of recovery and of failure to achieve recovery.

Presentation 9: Movements Of Coastal Cutthroat Trout (Oncorhynchus Clarki) In The Lower Columbia River: Tributary, Mainstem And Estuary Use

Joe Zydlewski, Columbia River Fisheries Program Office, U.S. Fish and Wildlife Service

Zydlewski reported on cutthroat trout research begun in 2001. The goals of the research are threefold:

1. Monitor juvenile and adult migrations to the mainstem using passive integrated transponder (PIT) tags and mainstem habitat use (radio and acoustic tags);
2. Analyze physiological indicators of smolting; and
3. Evaluate spatial patterns of historic catches.

PIT tag interrogation arrays were constructed in three lower Columbia tributaries: Chinook River, Abernathy Creek, and Gee Creek. The PIT tags used in this study measure 23 mm in length, instead of the more traditional 12 mm used in juvenile salmon and steelhead. These tags are being used to increase the effective detection distance. Antenna arrays have been constructed in each stream, consisting of an open coil conductor loop of multi strand wire strung through 10 ft. by 4.5 ft. PVC piping. The antenna can monitor the entire width and depth of a stream for PIT tagged fish, even under high water conditions. This allows virtually continuous (year-round at a 50 msec resolution) monitoring past a single point in a stream without obstructing the path of the fish. In addition, a portable backpack detection system was used to monitor individual trout movements within a stream. A stream survey with this apparatus allows location information for individual fish that do not move with high water events or at the end the predicted smolt migration. Radio tags (Lotek nano tag) and acoustic tags (Vemco V-8 coded pinger) were also utilized in this study. Passive and active tracking for the active tags was conducted (above the salt water wedge for radio tracking). This three point tracking system was used to provide descriptive population based data.

Because cutthroat trout exhibit a wide range of life history strategies, Zydlewski noted it was unknown if cutthroat trout exhibit “smolting” in the physiological sense. Specifically, whether cutthroat trout exhibit increased seawater tolerance during the period of migration and have elevated gill Na, K-ATPase activity (an enzyme linked to increased sea water tolerance). Results of this research suggest a smolting process and migration pattern comparable to other salmonids with regards to estuary use.

The study cutthroat indicated a directed spring migration with rapid directional movement to the estuary plume for residence (often within 5 days of entering the mainstem environment), and increased saltwater tolerance during in May and June. However the majority of measured movement is expected to take place in the spring of 2003.

Presentation 10: Food Web Dynamics In The Lower Columbia Estuary

Jen Zamon, Point Adams Field Station, NOAA Fisheries

The main question addressed in Zamon’s talk was what factor or factors limit growth or survival of juvenile salmon in the Columbia estuary. Her answer: the “usual suspects”, including food and habitat availability, predation, disease and parasites, and productivity. The majority of these factors specifically relate to food web dynamics. Salmonid growth and survival may be limited by the availability or quality of the food resources they exploit; or “bottom up” forces. They may also be limited by predators or disease from the “top down”.

Zamon focused her talk by first looking at the general background of the Columbia estuary food web pathways, and then reviewing present understanding of how salmon in the estuary are affected by bottom-up and top-down factors. Finally, she reviewed the outstanding questions regarding food web processes and salmon. For purposes of the talk, she divided the estuary into three regions: ocean/plume, estuarine mixing, and tidal fluvial. These regions are defined by temporally varying boundaries of salinity.

Zamon outlined four main sources of organic material to the Columbia River: rivers, tidally or seasonally flooded habitats, estuarine production in the mixing zone, and coastal ocean. Turbid water and a rapid flushing (2-5 days) rate limits primary productivity in the CRE. The food web therefore appears to be based on detritus, as opposed to primary (plant) production in the water column of the estuary itself. Macrodetritus appears to fuel the benthic food web, and microdetritus the pelagic food web. It is difficult to predict how quickly food web changes through anthropogenic effects such as pollution or invasion of nonnative species might impact salmon populations.

Juvenile salmon prey items in the estuary are diverse, and depend on salmon species/life history type, season, estuary location, and interannual variability in prey abundance. Stomach data imply that short-term prey availability is probably not limiting for salmon residing in the estuary for more than a few days (e.g., fall chinook and coho), as less than 20% of stomachs are empty, except in June and winter when up to 20% to 50% of stomachs have been found to be empty. The stomach content data also indicate salmon are linked strongly to several types of imported production: detrital food webs, insect production and in some cases freshwater cladorcerans. These “bottom up” relationships between different prey types, salmon condition, growth, and survival are not well understood, however.

Naturally occurring salmon predators in the estuary include fish, birds and mammals. Zamon indicated that fish predation is likely unimportant (two of greater than 5,000 piscivorous fish stomachs contained juvenile salmon during studies in the early 1980s). Zamon reports that bird predation in the 1990s removed 5% to 17% of juvenile salmon in the estuary, but this number is declining possibly due to recent active bird colony relocation efforts. Marine mammal predation (particularly seals and sea lions) has been difficult to evaluate directly. Efforts were begun in 2001 to analyze the effects of disease and parasites. Zamon indicated that total mortality in the estuary is also not understood fully, including specifically year to year variation. Overall, Zamon indicated that much the current knowledge base consists of a few years of data that is over 20 years old.

Zamon outlined four information needs relative to understanding food web dynamics:

1. Quantify relative importance of different food web pathways leading to salmon
2. Understand relationships among prey type, habitat vs. fish condition, growth, smolt-to-adult survival
3. Resolve total magnitude of mortality
4. Develop understanding of temporal variation in biological rate processes

Zamon noted that the temporal variability associated with the complex and dynamic structure, of the CRE, where both physical and biological features are constantly in flux, is especially challenging for scientists to characterize and interpret. She believes a first step in dealing with this variability is to establish some degree of continuity for research programs. She also believes it will be important for research programs to explicitly address this variability in both study design and data interpretation.

3. PANEL AND WORKGROUP DISCUSSIONS, AND WORKSHOP THEMES

After the presentations were concluded, the panel was asked to comment on a number of themes that had emerged during the day, while considering the following guiding questions:

- What are the strengths and weaknesses of the knowledge base?
- What are the key uncertainties in the knowledge base relative to successful restoration of salmon habitat?

Themes that were discussed included the use of historic information to compare with current conditions and identify potential target conditions, linking physical and biological processes and states, linking physical with survival models, scale influences on determining those linkages, identifying meaningful metrics for restoration, risks of not doing restoration work now, and data management and dissemination

These and other themes were discussed the following day during the breakout sessions, during which time other themes were also identified that are pertinent to understanding and restoring the CRE ecosystem. Three working groups were formed, each convening into different rooms. Each group was free to discuss whatever themes it wanted to, subject to key questions defined at the beginning of the workshop. The themes were discussed in the morning in terms of two guiding questions related to identifying research needs:

- What research would improve understanding of how various salmon life-history strategies function in the estuary?
- What research would substantially contribute to development and application of an ecosystem-based approach to salmon habitat restoration?

In the afternoon, themes were discussed with respect to two questions related to developing a research plan in the near term:

- What are the most important research needs?
- What are the main constraints to accomplishing the critical research?

The workshop concluded with a collective panel and audience discussion focused on the question:

- In light of what has been heard during the last two days, what research can and should be accomplished in FY2003, FY2004, FY2005 and beyond?

The various themes and respective discussions are summarized in this section. Rather than provide a chronological accounting and attribution of comments to the panel and breakout sessions, which discussed similar themes, this section presents a compilation and integration of comments for each theme and set of guiding questions. The information presented below is intended to be a reflection of the ideas and opinions of the workshop participants. In some cases, questions were raised but were not discussed among the workgroups. These questions are also included below under the appropriate theme.

3.1 DEVELOPING A CONCEPTUAL FRAMEWORK FOR ECOSYSTEM RESTORATION

It was generally agreed during the workshop that a conceptual framework would be helpful for focusing and evaluating future research and restoration efforts. The framework ideally would provide the road map for identifying relative importance of different factors influencing salmonid survival and ecosystem health, and for identifying the most important linkages between physical and biological processes. To that end, approaching this work from an ecosystem perspective with an eye to the big drivers (e.g. climate change and hydrology) is a positive step forward.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

Most conceptual frameworks to date have provided a moderate degree of certainty regarding what we know about estuarine processes, because they represent a synopsis of knowledge available at the time they were developed. Several conceptual models, preliminary or otherwise, are currently available. Of these, SARE appears to provide the most up-to-date framework for evaluating restoration needs in the CRE. However, the greatest uncertainty in SARE and other models concerns determining how to move to the next step, namely, how to make decisions that result in successful and more cost-effective restoration projects. An analogy might be that SARE provides a detailed shopping list but not a direct recipe. It is presently difficult to make decisions regarding where to best focus efforts using available frameworks.

IDENTIFYING RESEARCH NEEDS

The next five to ten years provide a window of opportunity to perform restoration and adaptive management activities, and to monitor biological responses in the Columbia River Estuary. A practical, decision-making framework would be helpful for focusing efforts during this window. Conceptual frameworks reflect what we currently know about how physical and biological systems work. Research that may contribute to an improved framework includes increased understanding of how anthropogenic factors have influenced salmonid life history strategies, and what a functioning ecosystem for the Columbia River should look like. Research focus at the landscape and site level was also mentioned as a need.

PRIORITIZING RESEARCH NEEDS

Existing conceptual models need to be brought together in a common framework, but most importantly, they need to be refined so that they can be used to make decisions regarding where efforts and resources should be most effectively allocated.

3.2 MONITORING, AND SELECTING MEANINGFUL METRICS AND PARAMETERS

The importance of monitoring restoration actions was emphasized repeatedly. Too many projects are constructed where baseline and follow-up monitoring are either limited or not done at all. However, it not always clear what should be measured as part of a monitoring program. Sometimes, monitoring protocol development takes precedence over implementation and interpreting the results. Critical issues include knowing what best to measure, whether the measurement reflects what we think we're measuring, and how to make decisions based on the measurements.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

There are numerous monitoring protocols available, including the Environmental Monitoring and Assessment Program (EMAP) that has been developed for the Columbia Basin. A long-term water quality monitoring plan is also in effect through the USGS but is not salmon oriented. The LCREP monitoring plan is extensive but should be revisited. A key uncertainty of the current knowledge base is that we do not always know how to make decisions based on what we are measuring.

IDENTIFYING RESEARCH NEEDS

The ‘if you build it they will come’ philosophy remains to be tested and evaluated through monitoring. Currently, this philosophy appears to be based as much on assumption as data. Research should focus on quantifying outcomes of different restoration actions. In addition, research should focus on quantifying metrics of life history and species diversity that can be monitored and related to changes in habitat opportunity. A sophisticated monitoring plan should be developed, and randomly selected monitoring sites used to extrapolate an overall plan. In particular, shallow water habitats need to be monitored. Metrics should be based on the goals. A definition of indicators and metrics needs to be created.

PRIORITIZING RESEARCH NEEDS

Simply the action of monitoring was identified as a high priority need. Restoration projects are experimental in nature, hence the great need for collecting relevant data for judging the success and appropriateness of different project types. Next to that, identifying what, where, and when to monitor is critical to learning from the data and information collected. This does not mean that a new monitoring protocol needs to be developed – there are a number of monitoring protocols exist that can be used. Determining how to make a decision from the data was identified as a priority, as was determining what metrics are really needed and useful for making decisions.

3.3 IDENTIFYING AND PRIORITIZING HABITAT CREATION AND RESTORATION OPTIONS

There are numerous opportunities for restoration in the CRE and for offsite mitigation, some known, some suspected, and others unknown. We need to move forward with restoration now while this window of opportunity exists, and not wait until we feel confident that we have enough data. If available resources are focused more on research, there is a risk of adversely affecting the ecosystem and salmon stocks by not implementing projects. However, we are limited in our ability to prioritize projects, which reflects the current state of knowledge. Which project types give us biggest "bank for buck" now, and which are more important for longer term recovery?

KNOWLEDGE BASE AND KEY UNCERTAINTIES

We believe we know what and how much habitat has been lost. We know what the ESA requirements are with respect to a target area (i.e., the 10,000 acres). Biological Opinion requirements are the current drivers of restoration, providing regulatory goals if nothing else. We do not know with great certainty, however, the answer to the question, "how much is enough?" Are 10,000 acres a suitable target condition, and how much ecological benefit will accrue from restoring that amount? Most projects that have been identified reflect an opportunistic approach. While not a bad thing, there is less certainty regarding identifying strategic projects. Effects on habitat complexity, diversity, and persistence were identified as possible criteria for prioritizing restoration sites.

IDENTIFYING RESEARCH NEEDS

A seven point research identification process plan was outlined by Brian Riddell under which most research needs could conceivably be addressed:

1. Delimit ecosystem boundaries/physical attributes
2. Outline habitat use by geography, species, stock (time and space)

3. Estimate mortality schedule by area, species and stock
4. Based on the above 3 identify ecosystem processes that are disrupted, and the cause
5. Project prioritization, goals and objectives defined
6. Research, Monitoring and Evaluation
7. Quantifiable sampling tools, techniques and standardized protocols should be developed and used

PRIORITIZING RESEARCH NEEDS

Prioritization of restoration project types and locations will depend on integrating the results of research related to the other themes addressed in the workshop (e.g., development of conceptual framework, identification of monitoring parameters and end-point targets), and to a certain extent social and political goals. Until the other themes are addressed more fully, highest priority for now relative to this theme may be monitoring so we know what projects work and what don't.

3.4 ENDPOINT (TARGET) DEFINITION

This was a critical issue, because both the Corps and NOAA Fisheries need to know at what point/stage an Action Item (and the FCRPS BO RPA) can be considered resolved and satisfied. In addition, there is the question regarding the definition of ecosystem: is it the salmonid ecosystem, the aquatic ecosystem, or the aquatic and terrestrial ecosystem that should be the objective for research and restoration efforts, and why?

KNOWLEDGE BASE AND KEY UNCERTAINTIES

There is currently no clear endpoint defined for restoration efforts because we do have limited knowledge of what the endpoint should actually be. Historic conditions provide a template of how the CRE system operated in the past, and could conceivably be used as a gage of restoration end-point. However, what period during the course of development of the CRE should we refer to? End-point definition is a key uncertainty that directly reflects uncertainty in what constitutes a sufficiently healthy estuarine ecosystem. Risk assessment could be a useful tool for addressing uncertainty.

IDENTIFYING RESEARCH NEEDS

There is a need for definition/identification of a restoration end-point, including identifying the appropriate historical reference frame (e.g., should we restore to 1964 conditions? Other?). The answer will depend on resolving questions such as, how dynamic should a system be to be considered "healthy." Increased diversity of wild salmon life history was indicated to be one potential measure of success, but more research is needed to identify suitable metrics.

PRIORITIZING RESEARCH NEEDS

Definition of a restoration endpoint was considered a high priority for identifying research gaps, strengths and weaknesses of the knowledge base, and to measure success of research efforts.

3.5 UNDER-USED, OLDER DATA

There is much historic information not being used to the full potential that it could be. Data mining was considered to be a high priority because the information exists already, and can be used to compare with other data to identify important data gaps. Some of those data have been considered or evaluated, but the general consensus was that additional useful information could be extracted for providing context, or potentially reducing the need, for new data.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

There are a number of data sets available. In addition to CREDPP, there is an extensive data set from the 1960's and 1970's residing at the NOAA Fisheries Hammond laboratory that contains extensive catch data on salmonid and non-salmonid species throughout the CRE.

IDENTIFYING RESEARCH NEEDS

Before spending significant sums collecting new data, we should mine all available historical data, analyze or reanalyze it, and not just rely on existing reports because they may not provide a complete picture, or may not have reported data in a format that can be used to address current questions. Appropriate data sets may warrant more detailed review and evaluation than has occurred to date.

PRIORITIZING RESEARCH NEEDS

This was identified as a highest priority need, over investing significant resources in extensive new data collection programs. The results should indicate what additional data need to be collected the most. This could also reduce the amount of handling of listed species by biologists.

3.6 INFORMATION ACCESS AND INTEGRATION

This theme pertains also to data that have been thoroughly analyzed. To maximize full advantage of available resources, it is important that information be readily shared, disseminated, and accessible to researchers and others working in the CRE. Available information should be kept up to date as often as possible.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

It is a strength of the knowledge base that much historical information has already been collected (e.g., fish sampling, physical habitat data and modeling, historical and current habitat mapping, etc.). We have a considerable source of information available, especially when compared with other systems, but limited access to that information can be a direct source of uncertainty.

IDENTIFYING RESEARCH NEEDS

We need to summarize how much of the current knowledge base is being summarized and translated, and whether it is useful and perceived to be widely available. It is important to synthesize information between agencies, disciplines, and science management teams in order to build a data management system and communicate knowledge. Information access should be made available to everyone, including perhaps a database of empirical and model simulation data. Efforts could include preparing a summary of other report recommendations (SARE etc.). Increased involvement is needed in Columbia River Estuary issues from local agencies, universities, and other NGOs. A proper level of stakeholder interest needs to be maintained.

PRIORITIZING RESEARCH NEEDS

Creation of a data clearinghouse with access to all was considered a high priority. Current and historical knowledge needs to be made widely available across disciplines, i.e. coordination and collaboration of integrated projects. In particular, a clearinghouse should be initiated for all of the data residing at the Hammond research station.

3.7 HISTORIC VS. PRESENT HABITAT CONDITIONS – HOW USEFUL, AND WHAT MORE CAN WE LEARN?

The CRE has undergone an integrated continuum of change, both natural and artificial, as opposed to experiencing clearly defined past, present, and future conditions. Much insight has been gained by compiling and evaluating available information on historical conditions in the CRE. This information not only provides an indication of the extent to which the CRE has changed, but can also provide insight into why it has changed, what factors have been most influential on the transition to the current ecosystem state, and what the range of target conditions might be. How much more can we learn by looking back in time?

KNOWLEDGE BASE AND KEY UNCERTAINTIES

Present knowledge of historical conditions is a strength of the knowledge base, because it can be used to identify what has been lost and what was considered “natural”. Lack of synthesis of existing information, and lack of baseline information on where the system was pre-disturbance are weaknesses of the knowledge base. Because possible irreversible changes have been made to the habitat it is recommended that we base research and restoration decisions on the current habitat state.

IDENTIFYING RESEARCH NEEDS

Historic conditions can provide research direction, but since large scale controlling factors like flow regulation and total habitat losses are not easily changed to the extent that those changes lead to a return to historic conditions, it was recommended we instead base decisions on where fish are using the habitat now. The current fish mix is different, habitat has changed substantially, exotic species are present in abundance, and we need to understand how these current states influence future potential. We probably should not spend too much time on historical analysis with respect to defining a target condition, because we will not be able to go back to the way things were historically. However, looking at historical conditions helps to understand how got where we are today, and where we are going in the future (climate change, water use etc.). We need to identify a restoration endpoint, which could be provided by history (e.g., restore to 1964 conditions). Historic conditions could also provide a "template" for current restoration, although we have yet to determine what is the best template.

PRIORITIZING RESEARCH NEEDS

There was some question as to how much more historical analysis is needed and what additional decisions can be made based on further work. We know roughly what has changed and why. What is perhaps a higher priority is identifying what more needs to be determined under the historical context and what other decisions can be made based on that knowledge. And, while we need to consider historic conditions from many perspectives, we should not wait for that analysis to be complete and slow current efforts to protect the fish.

3.8 HYDRODYNAMIC MODELING – DESCRIBING PHYSICAL PROCESSES

Hydrodynamic models of the CRE and plume provide a useful tool for evaluating changes in habitat quantity and quality, and understanding the interaction of tides, upriver flows, and bathymetry. The information resulting from such modeling can also be used to evaluate restoration options and biological responses. However, these models are extremely complex and data intensive.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

A moderate amount of bathymetric knowledge, particularly in deeper channel areas, was identified as a strength of the knowledge base. More extensive shallow water and historic data were identified as weaknesses. The ability to use hydrodynamic models to simulate velocities and depths under observed bathymetry and flows, and projected restoration alternatives, was identified as a significant strength. The ability to use hydrodynamic models to predict changes in bathymetry was identified indirectly as a weakness because the connection with sediment transport modeling and data is relatively weak. How to address physical, biological, and temporal scale differences was identified as a weakness, in that the mechanisms linking across different scales are not as well understood as they are at their respective scales. For that reason, rather than computing power limitations, modeling efforts are broken into distinct levels of scale. At present, linking physical changes to biological changes can only be done on a crude scale.

IDENTIFYING RESEARCH NEEDS

Bathymetric information was repeatedly identified as needed to fine-tune hydrodynamic models. Ultimately, the models may need to be able to predict hydraulic and water quality characteristics at the length scale of individual fish in order to link physical simulations with biological observations. Specifically, detailed bathymetric surveys of shallow water areas would assist in an ecosystem approach to salmonid conservation. It was noted that restoration disturbs the ecosystem, and that we need to think big picture, keep the overall plan in mind, and do it wisely. However, models must be scaled to the questions being asked. The smaller the scale the more difficult it is for the model to give an answer that works. Small scale models ignore habitat forming processes. Modeling may help evaluate if a factor is limiting or if instead the opportunity to use that factor is (i.e. food is present, but the current is too extreme for utilization). Chinook River is a project that could benefit from increased modeling capabilities, although such detailed modeling is not always necessary depending on the question(s) asked – simpler approaches may yield effectively similar results for less effort.

PRIORITIZING RESEARCH NEEDS

Although a high priority, it is currently not feasible to address the issue of translating across scales beyond simulating depth, velocity, and water quality. Until then, highest priority for hydrodynamic modeling is to collect more shallow water bathymetry data so that the model can more accurately quantify and catalog habitat opportunities in the CRE at intermediate to large scales. Note: a bathymetric survey of CRE shallow water areas is to be completed this summer as part of the Columbia River Channel Improvement Project (CRCIP).

3.9 SEDIMENT TRANSPORT AND FATE

Sediment budgeting analyses indicate the transport regime in the CRE has changed considerably, and that the amount of sediment exiting the mouth of the Columbia River may have been reduced in annual volume. Where is sediment being transported to, deposited, and at what rates? This is important for evaluating longer term sustainability of restoration projects such as wetlands and shallow water habitats. However, estuary sedimentation is a natural process altering estuarine habitats and creating coastal plains that occurs over long time scales, so it may be difficult to determine if adverse effects occur from changes in the transport regime to estuarine habitats using available data.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

Understanding how to predict influences of sediment transport on the current and future CRE geomorphology is considered a weakness in the knowledge base. Ability to model sediment transport within and through the system is a key weakness. We are uncertain as to the quality and quantity of the Columbia River sediment load relative to restoration potential, and how proposed restoration projects (including especially wetlands and tide flat habitat creation) will be affected over the long term by sedimentation processes.

IDENTIFYING RESEARCH NEEDS

Research is needed to understand how dredging, sand use, diking, other land uses, and restoration efforts influence transport, deposition, and erosion patterns throughout the CRE, and whether these changes would make a difference over the long term.

PRIORITIZING RESEARCH NEEDS

A high priority was assigned to developing an improved sediment budget for the CRE, but it was not discussed how to interpret the results in a restoration project context. A related priority action involves developing better sediment transport models for predicting changes in bathymetry that result from hydropower operations, dredging, sand extraction and dumping, diking, other land uses, and restoration efforts, as well as from natural forcings such as climate change, tides, and storms. This may be a difficult task, however, given the present level of uncertainty in sediment transport modeling in general.

3.10 HYDROGRAPH CHANGES

The FCRPS has resulted in significant changes to the annual hydrograph. To what extent have changes in peak flow influenced sediment transport in the CRE, and changes in lower flows influenced habitat availability? How mush flexibility does the USACE have to modify flows, would modifications in the hydrograph be meaningful, how would such changes compare with effects of other options involving changing boundary conditions, and how could changes in the hydrograph be effected?

KNOWLEDGE BASE AND KEY UNCERTAINTIES

It is not clear exactly how rigid the current operational constraints are, and how much operations can be modified to influence the Columbia River hydrograph. It is suspected that operational changes in the hydrograph resulting from the FCRPS BO RPA are less likely to effect significant changes in habitat opportunities and quality than changing the CRE boundary conditions (e.g., through dredging, dike removal, etc.). There has been some work on evaluating the influence of changes in the hydrograph on sediment transport.

IDENTIFYING RESEARCH NEEDS

We need to determine the constraints and flexibilities in the Columbia River water budget, and how the current hydrograph is limiting restoration potential. We cannot expect the hydrograph to change significantly, but we need to know how we can work within its limitations, and how best to manipulate it in favor of successful restoration. It is precisely because the water budget has limits that we need to be creative with the resources we have.

PRIORITIZING RESEARCH NEEDS

Highest priority lies with determining current and future operational and hydrologic limits of the FCRPS, and finding creative solutions.

3.11 LINKING PHYSICAL PROCESSES WITH BIOLOGICAL SYSTEMS

This was identified as a key theme in the workshop. It is possibly the most difficult of all the themes to address because we know relatively little about such linkages beyond quantifying habitat availability (i.e., the habitat opportunity metrics evaluated using hydrodynamic modeling). In addition, there is the issue of matching scales. The hydrodynamic models predict processes that act at large scales, whereas much of the biological data collected are at smaller scales. Individual fish likely respond to hydrodynamic processes at scales much smaller than can be presently modeled.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

There has been some linking of physical habitat with biological processes. There are detailed physical models available. Bottom's work has started the linking of biological and physical processes. How to match physical and biological processes across a wide range of spatial and temporal scales was identified as a significant gap in the knowledge base. For example, we do not know presently how to accurately link physical models with salmonid survival models, and what the corresponding level of variation in survival is considered acceptable. Also, we are not certain presently how to best relate biological parameters to CORIE.

IDENTIFYING RESEARCH NEEDS

It may be useful to utilize current available models to link historical physical habitat with biological processes. Some of this has been recently undertaken, but more would be better. Research habitat scale should match that of the question being addressed. It was recommended that whatever scale is used, it should cover the entire lower river, from Bonneville Dam to the plume. It was suggested that if the linkage is salmon-centric, one should look at the smallest tidal channel utilized by salmon, on a scale of meters. We also need to know the relationship between chemistry and productivity. So far, available physical models are far superior to available biological models, but have yet to achieve meter scale accuracy between Bonneville

Dam and the plume. Biological and physical linkages will need to be transferable between the landscape and site-specific scales. The work of Bottom et al. and Baptista et al. provide a starting linkage.

PRIORITIZING RESEARCH NEEDS

This overall theme was identified as a high priority research focus, but no approaches were proposed beyond continuing with linking habitat suitability metrics to hydrodynamic model predictions and focusing from Bonneville Dam to the plume. Identifying survival and physical model linkages, and if and how salmon production is actually limited in the CRE are also high priorities so that appropriate restoration decisions can be made. Monitoring may be the best way to address this currently until our understanding of the more fundamental linkages evolves.

3.12 SALMONID ABUNDANCE, HABITAT USE AND TIMING

Much data has been collected in the CRE that has indicated changes have occurred in salmonid population diversity, in terms of abundance, stocks, habitat use and timing. Such information can be linked with physical models of habitat availability. Some of that data has been evaluated thoroughly, other data have not. To what extent can we maximize the knowledge base using available data, and what data remain to be collected?

KNOWLEDGE BASE AND KEY UNCERTAINTIES

The lack of information available concerning the tidally influenced area between Bonneville and the estuary was identified as a weakness of the knowledge base. Other knowledge gaps include habitat selectivity and survival rates by species and lifestage and individual fish use and returns, i.e. where are the fish, and what are the chemical and habitat characteristics of site in context of river? Stock origin is a key uncertainty in most studies.

IDENTIFYING RESEARCH NEEDS

Enhancement of PIT tag and other tracking technologies would help develop an ecosystem-based approach to salmon conservation. Research focused on competition between hatchery and wild salmon would help with an overall ecosystem approach to conservation, as would inventory of fish distribution across the estuary. If we understand the loss of habitat, then we may be able to identify optimal locations, whether fish are using them, and then look at adjacent areas to restore as well. We are relatively ignorant of how salmon use the estuary; an issue that needs intensive sampling (fish and physical at same time) throughout the year, throughout the estuary. Habitat needs to be explicitly connected to growth and survival. A model should be developed for how species types use the landscape. Perhaps a biological map of the river at species level could be prepared.

PRIORITIZING RESEARCH NEEDS

Hatchery, PIT and coded wire tagging programs have been in place for different lengths of time. These approaches have great potential to provide considerable insight into salmonid juvenile behavior. We should take more advantage of these programs and implement more extensive sampling programs. Increased development and use of tagging technologies in general could greatly benefit estuary research. Re-examining older, under-utilized data should also be a priority in the context of this theme.

3.13 JUVENILE AND ADULT MIGRATION PATTERNS

There are a large number of life history strategies exhibited by salmon in the CRE. Some smolts spend relatively little time in the estuary, while others spend more time. How long each species and its different stocks and life stages spend in the estuary may provide an in indication of where restoration efforts are most needed.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

A weakness in the current knowledge base is information regarding salmonid residence timing by location. If a restoration project is implemented, will fish use it briefly or for a longer period? We do not know for sure if there are survival benefits to an extended estuarine residency, and what effect residing in the plume for different periods and times has on smolt to adult return ratios.

IDENTIFYING RESEARCH NEEDS

Extensive sampling, tagging, tracking, and related studies were identified as being needed to determine how juvenile and adult salmonids use the estuary and plume. This information is critical to determining the need and type of different restoration projects.

PRIORITIZING RESEARCH NEEDS

Fish sampling should place a high priority on determining migration rates, patterns, and site fidelity of both juveniles and adults. Sampling can be integrated with monitoring programs.

3.14 STOCK IDENTIFICATION, HATCHERY INFLUENCES, PHENOTYPIC EXPRESSION

It has been hypothesized that maintaining a wide variety of phenotypic expressions would benefit salmon stocks through increased resilience and robustness to environmental disturbance and longer term changes. Changing estuarine habitat and ocean conditions may influence some life history expressions more than others. Hatcheries have tended to lead to a simplification of life history strategies that may be likened to shifting towards a more vulnerable monoculture system.

Knowledge Base And Key Uncertainties

The extent of genotypic or phenotypic expression through habitat use patterns was identified as a significant weakness in the knowledge base.

Identifying Research Needs

It was indicated that maintaining and increasing diversity of life histories could be facilitated through increased habitat opportunity. We need to know what role hatchery production plays in the suppressing variation in life history expression, whether it is through competition, niche occupation, etc.. Quantitative genetic research is needed from fish samples collected throughout the CRE to identify how different stocks use the estuary.

Prioritizing Research Needs

Increased genetic research would provide valuable information concerning habitat utilization by different ESUs and stocks of salmon and trout.

3.15 WETLANDS FUNCTION

Wetlands serve as a water quality interface between terrestrial and aquatic environments, and provide food and detrital inputs that are important for food web dynamics. There have been significant losses in wetland area through diking and development. Wetland restoration or creation could provide an important means for achieving overall restoration goals.

Knowledge Base And Key Uncertainties

Uncertainty was expressed as to what makes and characterizes a “successful” wetland. There is uncertainty in conducting hydrogeomorphic assessments of tidal wetlands, and in determining the significance to salmon of tidal swamps and sub-tidal habitat separate from the main channel. We have limited models describing how different wetland functions can be restored in a tidal environment to increase salmonid survival. We are also unable to predict with reasonable accuracy how restored wetlands will be influenced by sedimentation over the longer term, which is relevant to evaluating sustainability of restoration projects.

Identifying Research Needs

Further studies of wetland function (e.g., predictive modeling and restoration) and measurement of wetland areas, including vegetation surveys and hydrogeomorphic assessments of wetland function were identified as important research needs.

PRIORITIZING RESEARCH NEEDS

Restoration approaches to wetland habitats and predictive modeling of their future condition were indicated to be a priority research need.

3.16 NUTRIENTS, DETRITUS, AND PRIMARY PRODUCTIVITY

The mode of detrital input to the CRE food web appears to have changed with development of the estuary from macro- to microdetritus. There is a question regarding the importance of detrital mode and primary productivity, and whether the change is limiting salmon production or survival. The linkages between primary productivity and ecosystem health are known generally, but specific attributes of the CRE ecosystem. The Estuary Turbidity Maximum (ETM) metric was considered in the channel deepening EIS and proposed here, but what remains to be determined is its linkage to successful restoration including identifying how specific actions can be designed to influence ETM in a meaningful way, and how to truly interpret a surrogate metric that changes dynamically in time and space.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

There appears to be a relation between the change from a macro- to a microdetritus based food web and juvenile salmon life history diversity and habitat capacity. It was noted, however, that there is little understanding of more detailed microbial ecology linkages. In particular, we do not know much about the ETM within the estuary regarding how it can be related to, or affected by, restoration, other than to note that it is correlated with productivity. A USACE-sponsored workshop was proposed through the channel deepening NEPA process to better understand processes and effects associated with the ETM. That workshop may provide a better sense of the importance of the ETM, and hopefully further elucidate differences between macro- and micro-detrital links to the CRE food web and production.

IDENTIFYING RESEARCH NEEDS

Participants were interested in knowing what it would take to return the system back to a macrodetritus based food web, and what the effects would be. In addition, research concerning nutrient supplementation could contribute to an ecosystem-based approach to salmonid conservation. We need to know more about the role of increased detritus stemming from habitat restoration.

PRIORITIZING RESEARCH NEEDS

Priority was attributed to better understanding the ecological differences between macro- and microdetrital based systems.

3.17 FOOD WEB DYNAMICS

In addition to primary production, higher levels in the CRE food web have undergone changes in how different organisms interact and feed. Present research is looking at how the food web influences juvenile salmon habitat use and survival, but we at best have presently a rough understanding of food web interactions in the CRE.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

As evidenced by Jen Zamon's presentation, our knowledge base is relatively good with respect to identifying specific linkages in the food web through stomach content surveys. We have a limited sense as to what matters with respect to juvenile salmon fitness and survival in the CRE and the ocean, however, as influenced by food web dynamics. We have a sense of what several limiting factors are, but not all.

IDENTIFYING RESEARCH NEEDS

A need was identified for better definition of food web pathways. Research on food limitation data for juvenile salmon would aid in an ecosystem based approach to salmonid conservation. It was recommended to further analyze food webs using both the top-down and bottom-up perspectives, to determine what eats salmon and what salmon eat, and how these influence the total magnitude of salmonid mortality in the CRE and ocean. Efforts should focus on partitioning survival by river location and different mechanisms (e.g., mammal and bird predation, sediment quality, etc.). A long term benthic and planktonic sampling program could be implemented to evaluate relationships among prey types.

PRIORITIZING RESEARCH NEEDS

Determination of the total magnitude and nature of salmon mortality in terms of feeding opportunity, food quality and quantity, and predation were identified as high priorities for research.

3.18 TRIBUTARY CONDITIONS AND OPPORTUNITIES FOR OFF-SITE MITIGATION

There are numerous tributaries to the lower Columbia River and CRE that support not only local salmonid populations, but that may also provide means for off-site mitigation that could still directly benefit different stocks originating from upriver.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

It is unknown whether water quality, particularly temperature, is limiting salmonid production in the Washington tributaries. Habitat is known to be limiting in many cases, and there are several approaches already available for implementation in smaller tributary systems that could lead to increased production and survival of salmonids using the CRE.

IDENTIFYING RESEARCH NEEDS

We need to determine how to balance research efforts between the tributaries and the mainstem estuary, and how to identify suitable restoration projects. Research concerning temperature conditions in tributary streams is needed.

PRIORITIZING RESEARCH NEEDS

Identification of opportunities for off-site mitigation was identified as a priority.

3.19 TOXIC CONTAMINANTS AND GEOCHEMISTRY

There is increasing awareness of the role that toxic contaminants may play in the estuary, but there is still much to learn. While direct (acute) toxicity is relatively well understood, chronic toxicity and bioaccumulation impacts on salmonid survival and fitness are less so. Toxicity may have a previously under-appreciated role in the estuary, including influencing the feasibility of specific restoration actions in areas subject to contamination.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

There is little knowledge of the role that low-level contaminants and emerging contaminants play in the estuary and in salmonid fitness. We know that there are elevated levels of mercury, lead, and polynuclear aromatic hydrocarbons (PAHs) in CRE and lower Columbia River sediments. However, sampling has been relatively limited, especially in the case of organic pollutants. We suspect that smolt fitness may be adversely affected by concentrations that are below ambient water and sediment quality criteria, but we are not certain as to the level of exposure needed.

IDENTIFYING RESEARCH NEEDS

Knowledge of contaminant history, including identifying sources, may be needed as part developing an ecosystem-based approach to salmonid conservation. We need to know if contaminants are present and available at levels of concern to fish and other aquatic biota. Contaminant research is an area needing greater focus.

PRIORITIZING RESEARCH NEEDS

Increased sampling of river bed sediments and geochemistry was identified as a priority, as was determining the pathways of contamination and uptake and if there are delayed mortality or reduced fitness effects that result from exposure. It would be extremely useful to form a subgroup to address and help frame specific questions regarding contaminants.

3.20 INVASIVE SPECIES

Planned and unplanned introductions of invasive flora and fauna have resulted in significant changes to the food web and habitat conditions in the CRE. The general consensus appears to be that invasives are 'bad' for juvenile salmon survival and habitat restoration, but we have little sense of exactly how 'bad'.

KNOWLEDGE BASE AND KEY UNCERTAINTIES

Specific interactions between invasive and native species in the CRE was identified as a weakness of the knowledge base. We can try to control invasives, but don’t know fully to what extent they adversely influence the success of restoration efforts.

IDENTIFYING RESEARCH NEEDS

Concern was expressed whether or not effects of invasive plankton species should be discussed and/or researched. We probably cannot control invasion, but it still should be addressed as a possible research need. Research should also be directed at whether introduced zooplankton species have affected feeding ability of salmon. Other invasive species specifically mentioned were American shad and New Zealand mud snails, and we need to know their effects on the native flora and fauna. We also need to know which invasive species are beneficial, inconsequential, and harmful to salmon recovery.

PRIORITIZING RESEARCH NEEDS

We need to know which species have greatest impact on restoration success and juvenile salmon survival and fitness, and how to design restoration projects to accommodate the problem of invasives.

3.21 RISKS ASSOCIATED WITH RESTORING 10,000 ACRES

The FCRPS BO calls for 10,000 acres to be restored. While we do not know where it would be best to create these areas, we should not wait with beginning because there is a risk that populations may continue to decline. In addition, there is the risk of unintended consequences depending on if and how the 10,000 acres are implemented, and whether the 10,000 acres is enough or too much. Further, if we wait, will changes in land availability in the future work for or against acquisitions and obtaining conservation easements?

KNOWLEDGE BASE AND KEY UNCERTAINTIES

It was suggested that restoration efforts cannot move fast enough to cause serious risk, because of resilience and responses of the ecosystem. It is uncertain how our current actions are impacting future conditions, and what the consequences are and whether actions taken now will be sustainable. The unknown effectiveness of "engineered" habitats was identified as a weakness in the knowledge base. In addition, we do not know if the 10,000 acres should be focused within a small area or spread out over a larger one.

IDENTIFYING RESEARCH NEEDS

We need to use models in a predictive manner, not just as a tool for analyzing history. We should learn as we go. We need to know if projects should all be implemented now, or should be staggered in time. We need to know what will happen to physical processes if and when restoration occurs (e.g., in terms of sediment and nutrient fluxes). We need to know what the effects are of changes in detritus quantity and quality (e.g., micro- vs. macro-detritus) from restoration efforts.

PRIORITIZING RESEARCH NEEDS

Highest priority appeared to be attributed to conducting restoration work in small increments, and monitoring the results. We should begin now during the present window of opportunity.

3.22 MISCELLANEOUS THEMES

There were a number of themes that were touched on but not addressed as thoroughly as the themes listed above. These included considerations of funding and land availability constraints, technological approaches, climate change, conventional water quality, and restoration options between estuary and Bonneville Dam. There were proponents for further research under each of these categories.

4. CONCLUSIONS

4.1 CONCLUDING WORKSHOP REMARKS AND SUMMARY

This two-day workshop provided the opportunity for attendees to participate in identifying research needs in the Lower Columbia River and estuary. Overall, the workshop participants agreed that due to the dynamic and diverse nature of the lower Columbia River system, the answer to research will also be diverse. Specific weaknesses of the knowledge base (research needs) identified repeatedly throughout the workshop include: linkages of the physical process models with biological processes, further exploration of sediment transport issues, hydrology and bathymetry (particularly shallow water areas). Connectivity (of habitat and research) and collaboration of researchers (sharing of knowledge) were themes also repeatedly identified.

In closing, Willis (ACOE) indicated confidence to move ahead with RPA 160 and 161. The Army Corps of Engineers will develop a plan, constructed in steps, that will allow review by other groups. Funding constraints are anticipated, but other funding avenues are available.

4.2 PROPOSED DRAFT RESEARCH PLAN BASED ON WORKSHOP DISCUSSIONS

A large number of themes were discussed during the workshop, and research needs were identified for essentially all of them. There was limited progress made regarding prioritization of the various research needs, however, and a specific research plan was not identified. The USACE has been directed through the FCRPS BO to develop a research plan, and hopes to build that plan using this workshop as a starting point. In particular, the plan should focus on implementing restoration actions as soon as possible, and be consistent with USACE authorities and funding constraints. Based on the collective comments made during the workshop, it was made clear that the plan should be focused, be as effective as possible (i.e., "biggest bang for buck" philosophy), build on a thorough foundation based on review and interpretation of existing data, and maximize collaborative opportunities.

4.2.1 Prioritization Of Future Research And Restoration Opportunities

All of the apparently higher priority action items that were identified in the workshop are summarized in Table 2. These items were identified based on the relative frequency with which they were identified, and the depth to which they were discussed. Table 2 also provides an assessment of the relative extent to which an item could potentially benefit salmon and the ecosystem, and the relative likelihood that the results will lead to those benefits based on what we know currently, and USACE authorization and funding constraints. The ratings in Table 2 should provide a useful means for developing the final USACE research plan in terms of certainty of success.

Table 2. Summary of research priority attributes for restoration and salmon recovery in the Columbia River estuary.

Research Element	Specific Actions Identified	Potential for Direct Benefits to Salmon	Potential For Direct Benefits to Aquatic Ecosystem	Certainty of Achieving Benefits	Ease of Implemen-tation
Developing a conceptual framework for ecosystem restoration	Bring together existing conceptual models into a common framework;	Moderate	Moderate	High	High
	Refine conceptual models for making decisions on resource/ effort allocation	High	High	Moderate	Moderate
Monitoring and selecting meaningful metrics and parameters	Perform pre- and post-research monitoring programs	Moderate	Moderate	High	High
	Identify specifically where, how and when to perform monitoring	High	High	Moderate/ High	Moderate
	Identify meaningful metrics needed for effective, results-oriented decision making	High	High	Low/ Moderate	Moderate
Identifying and prioritizing habitat creation and restoration options	Conceive monitoring protocols to determine which project types work and which do not	Moderate/ High	Moderate/ High	High	Moderate
	Identify which projects give the greatest reward for the least effort/cost	High	High	High	Moderate/ High
Endpoint (target) definition	Define appropriate restoration endpoints	High	High	Low	Low/ Moderate
	Use risk assessment to address uncertainty in defining success	Moderate/ High	Moderate/ High	Moderate	Low
Under-used, older data	'Mine' existing underutilized data	Moderate	Moderate	Moderate/ High	Moderate/ High
Information access and integration	Create clearinghouse of data to share (Hammond)	Moderate	Low/ Moderate	High	Moderate/ High
	Develop system-wide information and data access network/tool	Moderate/ High	Moderate	High	Low/ Moderate
Comparing historic vs. present habitat conditions	Continue increasing our understanding of historical habitat conditions and forming processes beyond what we have already learned	Low/ Moderate	Moderate	Moderate	Moderate
Hydrodynamic model data collection	Collect more shallow water bathymetry data	Moderate	Moderate	High	Moderate

Table 2. Summary of research priority attributes for restoration and salmon recovery in the Columbia River estuary.

Research Element	Specific Actions Identified	Potential for Direct Benefits to Salmon	Potential For Direct Benefits to Aquatic Ecosystem	Certainty of Achieving Benefits	Ease of Implemen-tation
Sediment transport and fate	Develop improved sediment budgets and transport models	Low/ Moderate	Moderate	Moderate	Low
Hydrograph changes	Determine current and future operational and hydrologic limits of the FCRPS and find creative solutions	Low	Low	High	High
Linking physical processes with biological systems	Continue linkage of habitat suitability metrics to hydrodynamic model predictions	Moderate/ High	Moderate/ High	High	High
	Identify survival and physical model linkages	High	Low/ Moderate	Moderate	Low
Salmonid abundance, habitat use, migration, and timing	Build on PIT and other existing tagging studies	High	Low	High	Moderate
	Reanalyze older or under utilized data	Moderate	Moderate	Moderate/ High	Moderate/ High
	Development and use of new tagging technology	High	Low	Moderate	Low
	Perform fish sampling	High	Moderate	Moderate	Moderate
Stock identification, hatchery influences and phenotypic expression	Additional genetic research	High	Low	Moderate	Moderate
Wetlands function	Implement projects to restore wetland habitats	Moderate	High	Moderate	Low
	Perform predictive modeling of future wetland habitat condition	Moderate	High	Low/ Moderate	Low
Nutrients, detritus, and primary productivity	Further measurement of the Estuary Turbidity Maximum (ETM) in the CRE and its importance for salmon	Unknown	Unknown	Moderate	Moderate
	Identify how specific restoration actions can influence the ETM	Moderate	Moderate	Low	Low/ Moderate
	Identify relative importance of micro- vs. macro-detrital sources and sinks	Moderate	High	Moderate	Low

Table 2. Summary of research priority attributes for restoration and salmon recovery in the Columbia River estuary.

Research Element	Specific Actions Identified	Potential for Direct Benefits to Salmon	Potential For Direct Benefits to Aquatic Ecosystem	Certainty of Achieving Benefits	Ease of Implemen-tation
Food web dynamics	Determine the total magnitude and nature of salmon predation	High	Moderate	Moderate	Moderate
	Establish long-term benthic and planktonic sampling program	Moderate	High	Moderate	Moderate
	Determine limiting food pathways for salmon	High	Moderate	Moderate	Low/ Moderate
Tributary conditions and opportunities for off-site mitigation	Identify opportunities for off-site mitigation	High	Low/ Moderate	Moderate	Moderate
Toxic contaminants and geochemistry	Increase sampling effort of river bed sediments and geochemistry	Unknown	Unknown	Moderate	Low
	Determine pathways and effects of contamination and uptake	Moderate/ High	Moderate/ High	Moderate	Low
	Formulate a contaminant study group	Moderate/ High	Moderate/ High	Moderate/ High	High
Invasive species	How to consider invasive species when performing restoration	Low/ Moderate	High	Moderate	Low/ Moderate
	Identify which species have the greatest impacts on restoration success	Moderate	High	Moderate	Low
Risks associated with restoring 10,000 acres	Continue restoration work in small increments and monitor the results; do not waste window of opportunity	Moderate	Moderate	High	High
Miscellaneous	Identify funding and land availability constraints	Unknown	Unknown	Unknown	Moderate/ High
	Determine effects of climate change on CRE ecosystem and salmon	Unknown	Unknown	Low	Low
	Increased conventional water quality sampling	Moderate	Moderate	High	High
	Evaluate restoration options between CRE and Bonneville Dam	Moderate	Moderate	Low	Low/ Moderate

Of the items in Table 2, it is possible to identify what appear to be highest research priorities based on the nature of specific comments made during the workshop. These priorities would likely form the core of the USACE's research plan. The following action items were identified repeatedly as actions that could be done now, and are interpreted here to be of highest priority:

- Move from a collection of available conceptual frameworks to an integrative implementation framework, where we combine what we have learned in the various conceptual frameworks to identify the most important areas for restoration actions, and what are the most likely avenues for success.
- Implement selected restoration projects as experiments, so that we can learn as we go.
- Implement pre- and post-restoration project monitoring programs, to increase the learning.
- "Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.
- Make more use of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.
- Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.
- Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.
- Identify and implement off-site mitigation projects in CRE tributaries.

The following items were identified as a high priority and could be implemented in the near term, but may not be directly applicable under USACE authorization constraints and are instead prime opportunities for collaboration under the overall CRE restoration framework:

- Establish a data and information sharing network so that all researchers have ready and up-to-date access.
- Increased genetic research to identify genotypic variations in habitat use

The following action items that were identified appear to be feasible within the present 10-year window of opportunity, but they may not be implemented immediately or lead directly to projects in the near term:

- Understanding salmonid estuarine ecology, including food web dynamics.
- Understanding sediment transport and deposition processes in the estuary.

- Understanding juvenile and adult migration patterns.
- Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.

The following action items may provide additional insights, but the incremental increase in resulting knowledge may not be as important as might occur from the preceding action items because we currently have a reasonable idea of the most important features based on preceding work:

- Increasing our understanding of how historic changes in the estuary morphology and hydrology have affected habitat availability and processes

The following items were identified as high priority, but will likely take the longest to complete before a tangible product is developed (these may also be good candidates for collaborative work using alternate funding sources):

- Improve our understanding of the linkages between physical and biological processes to the point that we can predict changes in survival and production in response to selected restoration measures.
- Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the CRE and ocean.
- Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.
- Improve our understanding of the role between micro- and macro-detrital inputs, transport, and end-points.
- Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.
- Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.

Above all, there is presently a tremendous knowledge base available for the CRE. It is tempting to focus on what we don't know because it seems that there is so much still to be learned, but we should not let ourselves feel overwhelmed by what we don't know and focus on what we do know. Many participants suggested that we should get going now with restoration efforts, recognizing that many of the critical questions raised in this workshop will probably not be answered to satisfaction in the next ten years. We can learn much more by treating restoration projects as experiments and monitoring them appropriately. Monitoring of current and future projects will provide us with much of the knowledge we need, and allow us to proceed according to adaptive management principles.

4.2.2 Direction For USACE Study Plan Development

Given funding, authorization, and likely timing (i.e., window of opportunity) constraints, the USACE may best develop a research study plan that focuses on implementing restoration projects now as experiments, with appropriate baseline and long term monitoring plans specific to those projects. This will most directly address the 10,000 acre focus stipulated in the FCRPS BO while also addressing many of the unknowns identified during the course of the workshop. In addition, the USACE plan can focus on the highest priority needs identified in this workshop that can be implemented in the near term and with highest benefits and certainty of success as projected in Table 2. Any measures that are implemented should rely on the principle of adaptive management and feedback.

4.3 RECOMMENDATIONS FOR FUTURE WORKSHOPS

Some of the issues identified here as requiring greater understanding could be addressed through formation of additional sub-group workshops. These workshops should focus as best possible on identifying priorities from the "shopping list" that will inevitably be developed, as was done in the present workshop. The breakout group concept worked well, and allowed different trains of thought to develop and focus on the same topic. This is important from a collaborative standpoint, especially because it allows identification of the more important topics through repetitive reference by different persons with different viewpoints, goals, and mandates.

5. LITERATURE RESOURCES

Bottom, D. L., K. K. Jones, and M. J. Herring. 1984. Fishes of the Columbia River estuary. Final report on the fish work unit of the Columbia River estuary data development program. Oregon Dept. of Fish and Wildlife, Corvallis. 113 p. plus appendices.

Bottom, D. L., C.A. Simenstad, A.M. Baptista, D.A. Jay, J. Burke, K. Jones, E. Casillas, and M.H. Schiewe. 2001. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. National Marine Fisheries Service, Seattle WA. 270p.

Columbia River Estuary Study Taskforce (CREST). 1995. Historic habitats of the Columbia River. 14 p. Available from www.Columbiaestuary.org

Dawley, E. M., R. D. Ledgerwood, and A. L. Jensen. 1985a. Beach and purse seine sampling of juvenile salmonids in the Columbia River estuary and ocean plume, 1977-1983; Volume I; Procedures, sampling effort and catch data. U.S. Dept. of Commer. NOAA Tech. Memo. NMFS, F/NWC-74: 1-260.

Dawley, E. M., R. D. Ledgerwood, and A. L. Jensen. 1985b. Beach and purse seine sampling of juvenile salmonids in the Columbia River Estuary and ocean plume, 1977-1983, Volume II; Data on marked fish recoveries. U.S. Dept. Commer. NOAA Tech. Memo. NMFS, F/NWC-75: 1-397.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, C. W. Sims, J. T. Durkin, R. A. Kirn, A. E. Rankis, G. E. Monan, and F. J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River Estuary, 1966-1983. Report to Bonneville Power Admin. DACW57-85-F-0623, 256 p.

Lower Columbia River Estuary Program. 1999. Biological Integrity Workshop. Proceedings of a workshop dated 13-14 May 1999 in Sandy Oregon. Prepared by Oregon State University, Sea Grant. 36 p.

Lower Columbia River Estuary Program. 1998. Lower Columbia River Estuary Plan. D. Garrett, editor. Volume 2: Aquatic Ecosystem Monitoring Strategy for the Lower Columbia River. 60 p.

National Marine Fisheries Service. 2000. Biological Opinion of Federal Columbia River Power System Operations.

Rich, W. H. 1920. Early history and seaward migration of chinook salmon in the Columbia and Sacramento Rivers. U.S. Bureau of Fish. Bulletin 37: 2-73.

Riemers, P. E. 1971. The length of residence of fall chinook salmon in Sixes River, Oregon. Fish Commission of Oregon Research Division. 99 p.

Sea Grant. 2001. Proceedings Sea Grant juvenile salmon estuarine habitat restoration workshop, February 7-9, 2001, Charleston, OR. Washington and Oregon Sea Grant program, Seattle, WA and Corvallis, OR.

U.S. Army Corps of Engineers. 2001. Proceedings of the Habitat Conservation and Restoration Projects in the Lower Columbia River and Estuary Workshop. Prepared in cooperation with American Rivers, CREST, and Lower Columbia River Estuary Program. Workshop date 12-13 June 2001, Astoria Oregon. Informational cd.

U.S. Army Corps of Engineers. 2002. Columbia River channel improvement project. Supplemental Integrated Feasibility Report and Environmental Impact Statement. Portland District. July.

Weitkamp, D. E. 2001. Estuarine habitat used by young salmon, an annotated bibliography. Parametrix, Inc. 91 p.

APPENDIX A

Workshop Agenda

Agenda

REGISTRATION	Agenda	Abstracts	PANEL & BREAKOUT QUESTIONS	Posters	TRAVEL & LODGING	WORKSHOP PARTNERS	HOME

Subject to Change without Notice

2003 Lower Columbia River
and Estuary Research Needs Identification Workshop

March 24 - 25, 2003
World Trade Center
Portland, Oregon

Monday, March 24	
Presentations by Key Researchers	
7:30-8:15 am	**Registration**
8:15-8:30 pm	**Welcoming Remarks**
8:30-8:45 am	**Background and Expectations** Bob Willis U.S. Army Corps of Engineers
8:45-9:15 am	**RESEARCH GAPS BASED ON PAST WORK AND CURRENT WORK** Bruce Sutherland Lower Columbia River Estuary Partnership
9:15-9:45 am	**HOW PAST RESEARCH HAS INFORMED DECISION-MAKING ON COLUMBIA RIVER ESTUARY RESTORATION AND FUTURE RESEARCH NEEDS** Cathy Tortorici NOAA Fisheries

9:45-10:15 am	**Break** *— coffee & pastries provided* *— posters on display*		
10:15-12:00 pm	**Current Research: Physical Environment**		
	Presenter	**Agency**	**Title**
	Antonio Baptista	OHSU/OGI	MODELING CIRCULATION IN THE LOWER COLUMBIA RIVER: STATUS AND VISION
	David Jay	OHSU/OGI	A UNIFIED VIEW OF RESEARCH NEEDS FOR THE COLUMBIA RIVER, ESTUARY AND PLUME
	Tarang Khangaonkar	Tetra Tech	HYDRODYNAMIC AND HYDROLOGIC FEASIBILITY ASSESSMENT - CHINOOK RIVER RESTORATION PROJECT
12:00–1:00 pm	**Lunch** *— lunch provided on-site* *— posters on display*		
1:00–2:45 pm	**Current Research: Salmon Biology**		
	Presenter	**Agency**	**Title**
	Ed Casillas	NOAA Fisheries	ASSESSING THE ROLE OF THE COLUMBIA RIVER ESTUARY IN GROWTH AND SURVIVAL OF JUVENILE SALMON
	TBA	NOAA Fisheries	NOAA TECHNICAL RECOVERY TEAM FOR THE WILLAMETTE AND COLUMBIA RIVERS

	Joe Zydlewski	US Fish and Wildlife	MOVEMENTS OF COASTAL CUTTHROAT TROUT (ONCORHYNCHUS CLARKI) IN THE LOWER COLUMBIA RIVER: TRIBUTARY, MAIN-STEM AND ESTUARY USE
	Jen Zamon	NOAA Fisheries	FOOD WEB DYNAMICS IN THE LOWER COLUMBIA RIVER ESTUARY
2:45-3:15 pm	**Break** *— posters on display*		
3:15–4:45 pm	**Panel Discussion: Research Strengths and Weaknesses**		
	Panelist		**Agency**
	Antonio Baptista		OHSU/OGI
	Earl Dawley		Consulting Biologist
	Steve Ellis		MCS Environmental
	Jim Good		School of Oceanography, OSU
	Brian Riddell		Independent Science Review Panel
	Ron Thom		Pacific Northwest National Laboratory
4:45–5:00 pm	**First Day Wrap Up**		
5:00–6:30 pm	**Social Hour and Poster Session** *— hors d'oeuvres provided* *— No host bar*		

Tuesday, March 25

Review of Day 1 and Breakout Sessions

8:30–9:00 am	**Registration**
9:00–10:00 am	**Summary of First Day** — organization of break out sessions — expectations for day
10:00–10:15 am	**Break** — transition to break out sessions
10:15–11:45 am	**Breakout Session I** Research Needs Assessment
11:45–12:30 pm	**Lunch**
12:30–2:00 pm	**Breakout Session II** Prioritization of Research Needs Identification of Constraints
2:00–2:30 pm	**Break**
2:30–3:45 pm	**Full Group Session led by Panel** — Review and Synthesis of Day 1 and 2 Results
3:45–4:00 pm	**Wrap Up and Adjourn**

APPENDIX B

Lists of Workshop Partners/Supporters, Attendees, and Workgroup Assignments

Table B-1. Attendee affiliations, contact information and role in the Lower Columbia River Estuary Research Needs Identification Workshop, 24-25 March 2003.

Last Name	First Name	Email	Organization	Address	City	State	Zip
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Table B-2. Lower Columbia River Estuary Research Needs Identification Workshop Partners and Supporters, 24-25 March 2003.

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OVERVIEW OF THE PANEL AND BREAKOUT SESSIONS AT THE LOWER COLUMBIA RIVER AND ESTUARY RESEARCH NEEDS IDENTIFICATION WORKSHOP

The Panel Sessions, at the end of both the first and second days, served as an opportunity for a group of experts to react to and engage in a conversation regarding the proceedings and what they have learned thus far.

Panel Discussion - Day 1

Panelists were asked to respond to two questions based on what they heard during the technical presentations and on their own knowledge of the lower Columbia River and estuary:

What are the strengths and weaknesses of the knowledge base?

What are the key uncertainties in the knowledge base relative to successful restoration of salmon habitat?

Breakout Session I - Day 2

All attendees were invited to participate in breakout sessions during the Workshop. Participants in the Session I breakout groups were asked:

What research would improve understanding of how various salmon life-history strategies function in the estuary?

What research would substantially contribute to development and application of an ecosystem-based approach to salmon habitat restoration?

Breakout Session II - Day 2

All attendees were invited to participate in breakout sessions during the Workshop. Participants in the Session II breakout groups were asked:

> What are the most important research needs?
>
> What are the main constraints to accomplishing the critical research?

Full Group Session Led By the Panel - Day 2

After the breakout sessions, a full group session was convened to discuss the following:

> In light of what has been heard during the last two days, what research can and should be accomplished in FY 2003, FY 2004, FY2005 and beyond?

APPENDIX C

Abstracts For Workshop Presentations

Presentation 1: Workshop Background And Expectations

Bob Willis, U.S. Army Corps of Engineers (USACE), Portland District.

No abstract.

Presentation 2: Research Gaps Based On Past Work And Current Work

Bruce Sutherland, Lower Columbia River Estuary Partnership

The Lower Columbia River Estuary Partnership is a nonprofit organization whose mission is to protect and enhance the ecosystem of the lower 146 river miles of the Columbia River and Estuary. Since 1996, the Partnership has been working aggressively with stakeholders on the lower river to develop and implement a comprehensive resource management plan. The Lower Columbia Estuary Plan contains 43 specific actions that address critical problem areas identified during the 1990 to 1995 Bi-State Water Quality Study. The problem areas include: a 50% loss of key habitats, elevated levels of conventional and toxic pollutants, public indifference, and institutional constraints.

A key part of the Estuary Plan is the Aquatic Ecosystem Monitoring Strategy. The Strategy, developed by a group of technical experts under the leadership of the U.S. Geological Survey, provides the framework for a comprehensive ecosystem monitoring program. It contains a series of recommendations for monitoring and research work needed to fill identified knowledge gaps and establish baseline conditions. The Strategy addresses data management, toxic contaminants, habitat, conventional pollutants, exotic species and food web interactions. The main elements of the Strategy are described, its implementation is discussed, and continuing information needs are highlighted.

The Estuary Partnership has also organized and co-sponsored three technical workshops aimed at addressing key resource management issues. The first, held in May 1999, focused on how to measure the biological integrity of the study area. The second, held in March 2001, focused on developing scientifically acceptable criteria for evaluating habitat conservation and restoration projects. The third, this years' workshop on research needs identification, will address what we still need to know to effectively implement ecosystem restoration. The results of the first two workshops and their relationship to research needs are discussed and tied into the broader issue of developing a collaborative approach to improving our knowledge base and to implementing salmonid recovery and ecosystem restoration.

Presentation 3: How Past Research Has Informed Decision-Making On Columbia River Estuary Restoration And Future Research Needs

Cathy Tortorici, NOAA Fisheries

A comprehensive analysis of available historical data and hydrodynamic models of the Columbia River estuary demonstrate that physical and ecological changes in estuarine habitat, combined with a simplification of salmon population structure and life-history diversity, have contributed to loss of salmon stocks.

NOAA Fisheries' December, 2000, Federal Columbia River Hydropower (FCRPS) Biological Opinion identifies a number of estuary related actions as off-site mitigation to improve salmon survival in the Lower Columbia River and estuary. Action 160 (Develop and implement an estuary restoration program with the goal of protecting and enhancing 10,000 acres of tidal wetlands, and other key habitats) and Action 161 (fund a monitoring and research program acceptable to NMFS) in particular relate to restoration and research.

Using the FCRPS Biological Opinion as an example of how past research can inform the implementation of these actions, the following restoration and research needs are identified:

- Protect and restore salmon access to forested wetlands and tidal floodplains;
- Expand the phenotypic diversity of salmon;
- Reconstruct historic changes in estuarine rearing opportunities and food-web linkages of Columbia River Salmon and evaluate their implications for managing river flows and restoring estuarine habitats;
- Monitor, on a long-term basis, the variations in salmon life-history diversity, habitat use, and performance in the estuary; and
- Develop the necessary tools to house, manage, and disseminate the data and information.

Presentation 4: Modeling Circulation In The Lower Columbia River: Status And Vision

Antonio Baptista, Oregon Health and Science University / OGI School of Science and Engineering (OHSU/OGI)

Modeling the circulation of the Lower Columbia River is a technically challenging task. Doing it in ways that inform both the scientific understanding and the regional management of the system adds logistical and political challenges. We discuss technical and non-technical challenges with a view for the future, in a multi-part presentation. We first provide a brief over view of the physical characteristics of the circulation in the lower Columbia River, with emphasis on the estuary and the plume. The overall picture is that of an extremely dynamic and non-linear system, very responsive to diverse and highly variable external forcings, including river discharges, ocean tides, and regional winds.

We then describe CORIE (http://www.ccalmr.ofi.edu/CORIE), the observation and forecasting system for the lower Columbia River that we have been developing since 1996. Designed as multi-purpose regional infrastructure, CORIE includes three integrated components: an observation network a modeling system, and an information management system. Main products are long-term observations, daily forecasts, and long-term simulations databases.

Besides CORIE, several modeling efforts have been developed for the Lower Columbia River over the years. We briefly review some of those efforts, chosen to cover various scales and purposes, from Bonneville Dam to the Eastern North Pacific Ocean. We conclude by proposing, as a strawman for discussion during and beyond the workshop, a vision for the integration of objective modeling and scientific understanding of Columbia River circulation in regional decision-making. Inherently collaborative, this vision accounts for the multiplicity of regional stakeholders, representing widely diverse missions, needs and technical expertise.

Presentation 5: A Unified View Of Research Needs For The Columbia River, Estuary And Plume

David A. Jay, Oregon Health and Science University / OGI School of Science and Engineering (OHSU/OGI)

The Columbia River Basin covers parts of nine states and two Canadian provinces, and the Columbia River plume influences the critical coastal upwelling regime from central Oregon to the Strait of Juan de Fuca. Because of this large geographic scope, it is often difficult to anticipate remote impacts of alterations of any part of the system. Climate change in interior tributaries may, for example have biophysical impacts that extend along the coast to the Canadian border. Ocean conditions may change the vital nitrogen input to mountainous tributaries from the carcasses of spawning salmonids. The reservoir system and navigational development have impacted the sediment budget throughout the Columbia River littoral cell. Willamette valley flood control measures may even have influenced supply of micronutrients to the plume. Formulation of wise management decisions often requires understanding such remote impacts, yet such attempts are limited both by scientific difficulties and multiple political and legal jurisdictions. This talk attempts to provide a unified overview of biophysical research needs for the Columbia River, estuary and plume. Resolving these issues will greatly improve our understanding of the complex interrelated physical, chemical, and geological processes that affect the region's marine ecosystems and salmon.

Presentation 6: Hydrodynamic And Hydrologic Feasibility Assessment-Chinook River Restoration Project

Tarang Khangaonkar, Tetra Tech / Foster Wheeler Environmental Corporation

A hydrodynamic and hydrologic modeling analysis was conducted to evaluate the feasibility of restoring natural estuarine habitats in the Chinook River estuary, located near the mouth of the Columbia River in Washington state. Prior to development, a 1,500-acre expanse of tidal marshes, complex networks of dendritic tidal channels, and peripheral tidal swamps characterized the estuary. The estuary likely provided important rearing habitat for juvenile salmonids originating from the Chinook River as well as the greater Columbia River Basin. Recent monitoring indicates that the abundance of salmonid species native to the Chinook River watershed has been significantly reduced from historic levels. One of the primary factors of this reduction is attributable to the construction in the early 1920s of a Highway 101 (HWY 101) overpass across the mouth of the Chinook River and a tide gate under the overpass. This construction, which was designed to eliminate tidal action in the estuary, has impeded the upstream passage of salmonids and removed physical processes that formed and maintained productive estuarine habitats. The goal of the Chinook River Restoration Project is to restore tidal functions through the estuary, by removing the tide gate at the mouth of the river, filling drainage ditches, restoring tidal swales and reforesting riparian areas.

Hydrologic and hydrodynamic models of the Chinook River estuary were developed to provide baseline information for the restoration project and to evaluate and design a restoration alternative that would best meet the project goal while also providing flood protection to properties upstream of Chinook River Valley road. The hydrologic model (HEC-HMS) computed Chinook River and tributary inflows for use as input to the hydrodynamic model at the project area boundary. Oregon Graduate Institute of Science and Technology's existing hydrodynamic model of the Columbia River estuary was used to develop the tidal boundary condition sin Baker Bay for the hydrodynamic model. The hydrodynamic modeled (RMA-10) was used to generate information on water levels, velocities, salinity, and inundation during both normal tides and 100-year storm conditions under existing conditions and under the restoration alternatives.

The major conclusion of the hydrologic and hydrodynamic modeling study is that restoration of the tidal functions in the Chinook River estuary would be feasible through opening or removal of the tide gate. Implementation of the preferred alternative (removal of the tide gate, restoration of the channel under Hwy 101 to a 200-foot width, and construction of an internal levee inside the project area) would provide the required restorations benefits (inundation, habitat, velocities, and salinity penetration, etc) and meet flood protection requirements. In addition, relatively little difference in the drainage or inundation upstream of Chinook River Valley Road would occur as a result of the proposed restoration activities.

Presentation 7: Assessing The Role Of The Columbia River Estuary In Growth And Survival Of Juvenile Salmon

John Ferguson (for Ed Casillas), Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service

The estuarine environment associated with the Columbia River, is a critical habitat to juvenile salmon. Recent evidence suggests that improvement in survival of the estuarine life history phase of Columbia River salmon may be critical to recovery of endangered stocks. In the case of salmonids originating from the Columbia River Basin, survival success hinges on the complex interaction of juvenile salmon quality and the abiotic and biotic river and ocean conditions at the time they enter into the estuarine landscape and during their first year of ocean existence. I will describe ongoing research that NOAA Fisheries along with our partners from academic institutions (Oregon Science and Health University, Oregon State University, and the University of Washington) and state agencies (Oregon Department of Fish and Wildlife and Washington State Department of Fish and Wildlife) are currently undertaking with regard to evaluating the role of the Columbia River estuary in recovery of depressed salmon stocks. Ongoing studies include (a) defining the role of the estuary in juvenile salmon growth and survival, (b) identifying linkages between the landscape and salmon that characterize salmon habitat, (c) developing applicable new technologies, (d) assessing the impact of human disturbance, and (e) developing approaches to facilitate evaluation of management action scenarios that can be used to restore the Columbia River estuarine habitat to benefit salmon growth and survival.

Presentation 8: NOAA Technical Recovery Team For The Willamette And Columbia Rivers

Tom Clooney, NOAA Fisheries

No abstract provided

Presentation 9: Movements Of Coastal Cutthroat Trout (Oncorhynchus Clarki) In The Lower Columbia River: Tributary, Mainstem And Estuary Use

Joe Zydlewski, Columbia River Fisheries Program Office, U.S. Fish and Wildlife Service

Investigations on the timing and extent of movements by coastal cutthroat trout were initiated in 2001 in order to provide critical information on estuary and mainstem habitat use. Approaches focused on juvenile movements. Monitoring smolt emigration, adult return, and the prevalence of juvenile excursions into mainstem and estuarine habitat involved the construction of stationary PIT tag (Passive Integrated Transponder) interrogation arrays in three Lower Columbia tributaries, Chinook River (6 km), Abernathy Creek (76 km) and Gee Creek (128 km). In these tributaries, 448, 455, and 32 fish respectively were captured by electro-fishing and implanted with a 23 mm PIT tag. Movements past interrogation arrays are anticipated in the spring of 2003. Timing and speed of juvenile migration was investigated using both active and passive radio and passive acoustic telemetry in the spring of 2002. In Abernathy, Mill (75 km) and Germany Creeks (79 km) a total of 96 juveniles were implanted with digitally coded radio transmitters. In these tributaries and the Chinook River, a total of 49 juveniles were implanted with coded pingers. Of these tagged fish, movement data from 91 (95%) and 32 (65%) of these tagged fish were recorded. These data suggest that migrant cutthroat trout leave the tributaries and make rapid, directed movements into seawater, often within 5 days of entry into the mainstem environment. Physiological data (increased gill Na, K-ATPase and increased seawater tolerance during the spring) further suggests a smolting process and migration comparable to other salmonids with regards to estuarine use.

Presentation 10: Food Web Dynamics In The Lower Columbia Estuary

Jen Zamon, Point Adams Field Station, NOAA Fisheries

This talk provides an overview of what is known about food web dynamics in the Columbia River estuary, particularly as they relate to bottom-up and top-down effects on juvenile salmon. From River Kilometer 75 to the mouth, the estuary is a complex, dynamic mosaic of channels, shoals, bays, and wetlands. For purposes of this talk, the estuary can be divided into three regions with temporally – varying boundaries defined by salinity (ocean /plume, estuarine missing, and tidal fluvial). The organic material used by primary consumers enters estuarine food webs from four main sources: rivers (as freshwater phytoplankton or organic debris), tidally or seasonally flooded habitats (as benthic algae or organic debris from wetland plants), estuarine production in turbidity maxima (as particle-attached microbes), and the coastal ocean (as marine phytoplankton). Primary production by phytoplankton, algae, and sub-surface vascular plants is light-limited due to very shallow light penetration in the water column (photic zone < 2,5 m) and rapid flushing time in the estuary (2-5 days). Decaying organic material (detritus) appears to be the main energy source for many primary consumers, with macrodetritus from wetland habitats fueling the benthic food web, and microdetritus from freshwater phytoplankton fueling the pelagic food web. However, the relative importance of different sources of macro- and microdetritus to food web pathways leading to salmon has yet to be determined, and the extent to which invasive species might alter these pathways is not understood.

Prey types taken by juvenile salmon in the estuary are diverse, and depend on species/life history type, season, estuary location, and interannual variability in prey abundance. Stomach content data imply salmon are linked strongly to several types of imported production: detrital food webs, insect production, and in some cases freshwater cladocerans. The gammarid amphipod Corophium salmonis, along with other epibenthic crustaceans, are important prey to most salmon species using the estuary. Stomach data imply that for chinook and coho residing in the estuary for more than a few days, short-term prey availability is not limiting (less than 20% of stomachs are empty), except in June and winter (when up to 20% to 50% are empty). However, little is known about the ecological causes of changes in prey availability (especially interannual changes); relationships between diet, prey consumption rates, and growth in different habitats; movement patterns of estuary-resident juveniles among different habitats; or the relationship between estuary feeding conditions and smolt-to-adult survival.

Fish predation on juvenile salmon in the lower estuary is thought to be unimportant. Surveys in the early 1980s found only two of over 5,000 predator stomachs contained juvenile salmon; no northern pikeminnow stomachs contained juvenile salmon. During the 1990s, bird predation, especially by breeding Caspian terns, removed on the order of 5 to 17% of juvenile salmon entering the estuary. This predation pressure has been reduced by moving the tern colonies to the Ocean/Plume environment where the birds consume less salmon and more schooling marine fishes. Predation by marine mammals – primarily harbor seals and sea lions – has been difficult to evaluate. Work to obtain indirect estimates from pinniped population estimates and scat analysis is in the early stages. Salmon parasites and disease known to cause mortality in freshwater environments are present in the estuary; work to determine their role in the estuary began in 2001. Anthropogenic mortality agents (e.g. acute or chronic pollution, bioaccumulation of contaminants) are not thought to be significant, although studies in the lower estuary are limited.

One of the most significant challenges facing salmon research in the lower estuary is dealing with strong temporal variation across multiple time scales (tidal, seasonal, interannual) within a spatially complex landscape. This is especially true for biological measurements and rate processes, which unlike physical processes often cannot be measured with high temporal resolution (except perhaps for primary producers), cannot be interpolated across large spatial scales, and do not necessarily remain similar among years.

APPENDIX D

Subsequent Comments Provided Regarding Workshop

Comment 1 – J. Rinella USGS – 4 April 2003

Chemical processes are a critical determinants of habitat quality for salmonids, and they should be explicitly addressed at the outset of any restoration efforts (wetlands or otherwise). Up here in Seattle, we have adult coho salmon that are dying when they come back to spawn in small urban streams. Many millions of dollars have been spent to restore "habitat" in these systems, with a near-exclusive focus on physical processes. Longfellow Creek in West Seattle is a regional model for stream restoration, and we observed almost 90% adult pre-spawn mortality across the entire 2002 coho run. The problem appears to be degraded water quality.

The sooner people integrate chemical processes into the "habitat" perspective, the better. This is particularly true of agricultural and urban/urbanizing watersheds. Otherwise, restoration projects will continue to make the landscape look nice, without addressing the health of the underlying ecosystem or the salmonid species in question. The urban stream problem should be viewed as a case study in salmon habitat restoration - something we can learn from.

Comment 2 – NOAA Fisheries Hydropower Division – 27 March 2003

1. What is the potential to restore/improve the various salmonid habitat types in estuary? 10K acres? 50K acres? (at a reasonable cost).

2. Of the limiting factors identified in estuary or Columbia River plume, prioritize those that have management implications, i.e., identify those that we have ability to change or manage. (flow changes, iron input, etc.)

3. Need to work on developing the linkage(s) between the physical characteristics of estuary and plume and salmonid utilization of various habitat types, especially for ocean-type salmon like fall chinook and chum – also need to identify how climate change/global warming may alter the physical characteristics and available habitat in estuary.

Comment 3 – Tracy Collier, NOAA Fisheries Northwest Fisheries Science Center – April 10, 2003

Cathy, Thanks for sending on Joe's comments regarding research needs in the LCR estuary. Here are our thoughts to add to the general mix, and for your consideration following the workshop. The first several items below are derived from what was presented at the workshop, and the last several items derive from the discussions in the breakouts groups and our own recommendations:

- Juvenile outmigrant chinook salmon are accumulating appreciable levels of toxic contaminants before they leave the LCR estuary, and the levels are among the highest seen in any populations we have examined to date up and down the OR and WA coasts.
- Part of this contamination comes from hatchery feeds, for the bioaccumulative contaminants such as PCBs and DDTs, but we know that salmon are also exposed via contaminated prey items in the LCR. PAHs, though not bioaccumulative in fish, are still toxic, and salmon collected at the confluence of the Willamette and Columbia Rivers show evidence of PAH exposure as well.
- The sources and fluxes of contaminants in the LCR estuary are not characterized. We have very little information as to how salmon and other species are being exposed, such as the relative contributions from upstream sources vs lower river off-channel sources vs hatchery feeds.
- We have very little information on contaminant body burdens in hatchery fish vs. wild listed stocks. Wild fish will not have the extra exposure from feed that we see in hatchery fish, but they also may remain in the estuary longer and accordingly have more potential to take up contaminants from the environment. We do know that off-channel habitats, where wild juvenile salmon tend to be found, are the areas with comparatively higher levels of chemical contaminants in sediment and presumably prey.
- The biological consequences of the current levels of exposure are not known, but body burdens of PCBs are near levels of concern, as described in Meador et al., 2002. Because fish are exposed to multiple contaminants, concern is increased in our view.
- Because of the critical nature of estuary use for several populations of Pacific salmon with different life histories, toxic contaminant exposure poses a significant uncertainty in considering recovery efforts for Columbia river stocks.

An RM&E component focusing on chemical habitat issues is crucial, and we concur with the comments in Joe Rinella's memo to you. There was a strong sentiment expressed by a number of people for a renewed toxics monitoring program in the LCR, which we also concur with.

However, it is very clear that there needs to be LCR-focused research in a number of key areas, including:

-- Identification and quantitation of sources of toxic contaminants which are contributing to the exposure of salmon leaving the LCR.

-- Determination of the biological consequences of contaminant exposure in salmon, as well as consequences for other species, notably prey species and higher trophic levels (e.g., piscivorous birds). This would include more accurate estimates of threshold effects concentrations for contaminants of concern.

We have a reasonable estimate for PCBs (though this could be refined with additional data). However, we critically need threshold estimates for DDTs and PAHs. Other contaminants of concern include some that are not currently regulated (e.g. pharmaceuticals, fire retardants, some current use pesticides).

-- Characterization of exposure patterns in wild vs. hatchery fish, in populations with different life histories and patterns of estuary use, in various listed ESUs. This would require genetic ID of various populations so we know where fish are coming from.

-- Contaminant transport in suspended particulates, e.g. in ETM. Does this phenomenon contribute to contaminant uptake in fish? Finally, it was generally recognized that contaminant monitoring and research should be conducted as part of overall investigations of chemical habitat quality, as alluded to in Joe's memo to you. Included in this effort would be studies of organic carbon transport and cycling. Chemical habitat quality should also be incorporated into modeling efforts.

We need to follow up on these identified uncertainties and research questions, preferably under the current efforts for RM&E in the LCR. I would appreciate your views as to the best way to proceed.

Tracy

Dr. Tracy K. Collier Program Manager Ecotoxicology and Environmental Fish Health ECD, NWFSC, NOAA-F (206) 860-3312 office (206)369-2779 cell HTTP://RESEARCH.NWFSC.NOAA.GOV/EC/ECOTOX/

APPENDIX E

Flipchart Notes From Breakout Workgroup Discussions

FLIPCHART NOTES – BREAKOUT SESSION 1

STRENGTHS OF THE KNOWLEDGE BASE

- Did not address further

WEAKNESSES OF THE KNOWLEDGE BASE

- Did not address further

KEY UNCERTAINTIES IN THE KNOWLEDGE BASE

- Did not address further

QUESTION 1: WHAT RESEARCH WOULD IMPROVE UNDERSTANDING OF HOW VARIOUS SALMON LIFE-HISTORY STRATEGIES FUNCTION IN THE ESTUARY?

QUESTION 2: WHAT RESEARCH WOULD SUBSTANTIALLY CONTRIBUTE TO DEVELOPMENT AND APPLICATION OF AN ECOSYSTEM-BASED APPROACH TO SALMON HABITAT RESTORATION?

- Contaminants.
- Temperature conditions in tributary streams.
- Building data management system and communicating information.
- Linking biology and physics.
- Synthesize between agencies, disciplines, and science and management.
- Biological inventory and map of river at species level.
- Linkage of biology and physics and translation at landscape and site specific scales.
- How much of current information is being summarized and translated – is it useful?
- Juvenile abundance and distribution by habitat types. Where are they found, what are the chemical and habitat characteristics of site in context of river?
- What fish are using the estuary, what is the location of use, what is the amount and duration of use?
    - What methods can be employed to increase understanding?
- Reintroduce Chum and Fall Chinook so that they can be studied.
- Nutrient supplementation
- Bathymetry, bathymetry, bathymetry

QUESTION 3: WHAT ARE THE MOST IMPORTANT RESEARCH NEEDS?

Note that the ✷'s below indicate research proposed in response to the first two questions.

- Collection of additional data to increase understanding of estuary.
    - ✷ Contaminants
    - ✷ Biological inventory and map of river at species level
    - ✷ Juvenile abundance and distribution by habitat types. Where found, what are chemical and habitat characteristics of site in context of river?
    - ✷ What fish are using estuary, what is the location of use, what is the amount and duration of use.
- Translating Physics to biological functioning of the Columbia River System.
- Translate (maps), communicate existing knowledge to public/decision makers.
    - ✷ Building data management system and communicating information.
    - ✷ Biological inventory and map of river at species level.
- Physical processes – sediment, nutrient flux – that will happen if restoration occurs.
- Is there a balance in focus on the main stream estuary and tributaries?
- Biotic change including introduced species.
- Re-assess the existing biological data
    - Re-analyze beyond existing reports
    - Know limitations of data being analyzed
    - Institutional knowledge catch

QUESTION 4: WHAT ARE THE MAIN CONSTRAINTS TO ACCOMPLISHING THE CRITICAL RESEARCH?

- Money
- Multiple/conflicting mandates for the Army Corps of Engineers.
- Hydropower, Hatchery, Harvest.
- Availability and access to existing knowledge.
- Insufficient taxonomic detail on Columbia River biota.
- Identification of salmonids and sampling intensity to determine estuarine utilization.
- Lack of blueprint for how research fits together and order to be addressed
- Institutional constraints (federal, state and local agencies).

FLIPCHART NOTES – BREAKOUT SESSION 2

STRENGTHS OF THE KNOWLEDGE BASE

- Approaching work from an ecosystem perspective, and with an eye to big driver (e.g., climate change)
- Preliminary conceptual model
  - Fish predation questions
- Attempts to link physics and biology
  - Efforts underway

WEAKNESSES OF THE KNOWLEDGE BASE

- Tidally influenced area between Bonneville and the estuary
- Role of invasive species
- Knowledge of primary productivity
- “Adult” – habitats, etc.
- Role of low-level contaminants and emerging contaminants
- Existing geomorphology
- Microbial ecology – to understand links
- Don’t know how to describe what we are measuring

KEY UNCERTAINTIES IN THE KNOWLEDGE BASE

- How are actions now going to impact the future?
  - Consequences
  - Sustainability
- Evaluation capacity
  - How do we process information?
  - Who makes the decisions?
- Endpoint not clearly defined
  - Needed for clarity and to identify gaps, strengths, weaknesses, etc.
- How dynamic does the system have to be in order to be healthy? (How far do we need to go?)
- Lack of baseline information on where the system was pre-disturbance
- Quality and quantity of sediment load as it relates to restoration potential

QUESTION 1: WHAT RESEARCH WOULD IMPROVE UNDERSTANDING OF HOW VARIOUS SALMON LIFE-HISTORY STRATEGIES FUNCTION IN THE ESTUARY?

- Understanding of anthropogenic factors
- Hammond database (data recovery)*
  - Need to mine the data
  - Catch data from many sites throughout estuary/shore: 64-74, 77-84
- Limitations on techniques to identify what stock, ESU fish from
  - Need more information than just hatchery vs. wild differentiation)
- Look to other reports' recommendations
- Focus on estuary but need to recognize that fish come from all over system
  - Focus on ESUs

QUESTION 2: WHAT RESEARCH WOULD SUBSTANTIALLY CONTRIBUTE TO DEVELOPMENT AND APPLICATION OF AN ECOSYSTEM-BASED APPROACH TO SALMON HABITAT RESTORATION?

- Function of wetlands as:* (ecosystem perspective)
  - Filter for contaminants
  - Habitat for species
  - Nutrient supply source
  - Sediment trapping
  - Accretion rates
- Contaminant history
- Competition between hatchery and wild salmon
- Potential competition with American Chad*
- Inventories of where fish are distributed across the estuary
  - Concern with only going to inventory
- Food limitation data
- In-lab experiments getting at mechanisms by which habitat affects fish performance
- What would it take to get system back to "macrodetritus"?
- How much do the yearlings use the estuary?
- Pit tagging technology enhancements
- Genetics information
- Ecosystem focus
  - e.g., contaminants, yes for impacts on fish, but think more broadly
- Resolve conceptual models
  - Research to identify any weaknesses in the conceptual model
- Research aimed at creating a long-term database to determine temporal and spatial variability in primary and secondary production (as it relates to salmonids)*
- Estuarine turbidity maximum*
  - Where is it located?

- Movement?
  - Macrodetrital/micro?
  - Corps workshop?*
- In considering conceptual frameworks – derive into decision making tool
  - Adaptive management – (are you meeting goal or not? Why?)
- Detailed bathymetric survey
- Flow
  - What are the constraints?
  - Can they be manipulated differently?
- Dredging
  - How can we use the sand?
  - Variety of options
- Conceptual model?
  - Given what you know, how close are we to broad buy-in to one CM?
  - How much effort would it take to get there?
    - Social exercise to agree on format
- Assessment of potential sediment loading resulting from land recovery/reclaim efforts
  - linkage with hydrodynamic model to see where sediments may be depositing
- Summary of all other recommendations (SARE, etc) or the workshop CD
- Long-term benthic and plankton sampling program
- Good measures of fish health and fitness
  - Continued support of existing efforts
- When looking at food web – not just what fish eat but what eat fish (birds, mammals)
- Contaminants – levels of concern for fish

QUESTION 3: WHAT ARE THE MOST IMPORTANT RESEARCH NEEDS?

*Note that the *'s above (in questions 1 and 2) indicate additional priority areas*

- Data mining
- Monitoring of on-going/new restoration
  - Or an overview of what others should be focusing on
  - How do you measure success?
- Integration of efforts (non-federal and federal) to restore estuarine processes
  - LCREP
  - Share information
- Links between physics and biology
  - Database of observed/simulations data
  - Access to everyone

  - Physical habitat opportunity
- Wetlands studies/functions
  - (Predictive modeling)
  - Restoration
- Monitoring – not just create a protocol but have to implement, get results
- Maintain PIT tagging technology in the estuary
  - Variety of sources (ESU's)
- Adults role in the plume or estuary
- Create/continue improving tracking technology
  - Survival estimation
- Salmonid life-history use in the estuary
- Integrative projects – should be major criteria for research
- Regional Mapping
  - Fish habitat, channels (accessibility)
  - Vegetation surveys (elevations of plants)
  - Available acreage
  - Substrate
  - Bathymetry
  - Primary productivity (remote sensing)
  - Topography
  - Accessibility (10,000 acres)
- Take advantage of ongoing efforts (especially tidal wetlands)
  - What do we need to know to make sure they will be successful?
  - How the system works -> very applied
- Criteria for habitat selection and prioritization
- Information necessary to measure success
- Have to maximize probability of success
  - Will lead to more money

QUESTION 4: WHAT ARE THE MAIN CONSTRAINTS TO ACCOMPLISHING THE CRITICAL RESEARCH?

- Restoration timelines and knowledge available not always in sync – rather both moving and need to build off each other
- Stakeholders and general public seem to be driving these efforts more than they should be (based on limited knowledge)
- Math analogy – elegant solutions vs. brute force
  - Complexity/dynamic system
- Modern hydrograph in the Columbia

  - Variability over time will require really long-term commitment
- Access to land
- Funding
- Research on metrics of performance

FLIPCHART NOTES – BREAKOUT SESSION 3

STRENGTHS OF THE KNOWLEDGE BASE

- No additional strengths identified

WEAKNESSES OF THE KNOWLEDGE BASE

- Tidally influenced area between Bonneville and the estuary
- Residence time
- Habitat selectivity
- Survival rates by species and stage
- The effects of engineering habitats (to the extent this may occur in restoration)
- Tidal swamps
- Sub-tidal habitats separate from the main channel
- Hydromorphic assessment for tidal wetlands; draft models for different wetland functions
- Lack of synthesis of existing information
- Individual fish use and returns
- Method to measure what processes form and affect habitat and how to return to those

KEY UNCERTAINTIES IN THE KNOWLEDGE BASE

- Need for definition of food web pathways and bio-connectivity*
- Wetland functions, including what makes "successful" wetlands

QUESTION 1: WHAT RESEARCH WOULD IMPROVE UNDERSTANDING OF HOW VARIOUS SALMON LIFE-HISTORY STRATEGIES FUNCTION IN THE ESTUARY?

- Pit-tags, new technologies
- Ability to resolve temporal variability
- Understand full sequence of habitats fish use
- Connect habitat to growth explicitly, not short-term growth measures, e.g. nutritional value for fish
- Genetic structure of populations
- "If open up habitat type again, will fish use it?"
- Construct models for how species types use the landscape
- How phenotypic expression of habitat use is related to genotype; measure through quantitative genetics*
- Life history diversity, broadly

- Strategic approach focus on restoration learning experience
- Maintain big picture context and use focused processes to evaluate within it

QUESTION 2: WHAT RESEARCH WOULD SUBSTANTIALLY CONTRIBUTE TO DEVELOPMENT AND APPLICATION OF AN ECOSYSTEM-BASED APPROACH TO SALMON HABITAT RESTORATION?

- Measure wetland areas
- Synthesis/integration of historical information including:
  - Hydrodynamics
  - Bathymetry
  - Sedimentation
  - Habitats themselves
  - Life history
  - Habitat use patterns
- Hierarchy of measurement approaches, rapid assessment technique and HGM approach to wetland function
- Coordination for synthesis of existing data and an overall look at current efforts
- Research that connects salmon growth and survival to habitats
- Survival measurements
- Residency and movement; connectivity of spatial scale
- Connection between physical and biological processes
- Management and research connection mechanism, partnerships and critique of existing efforts
- Definition of indicators and metrics
- Coordination of restoration activities and monitoring
- Review existing methods and efforts
- Survival-mortality broken down by river, mammal, bird predation, sediment, turbidity, etc.
- Monitoring driven by goals and objectives; scaled appropriately
- Information from Jones Beach to Bonneville*
- Link to returning adults
- Flux times of things through the system to build timeframe for evaluation of restoration efforts
- Institutional barriers including an assessment of organizational mandates, opportunities for cooperation, landowner involvement, etc.

QUESTION 3: WHAT ARE THE MOST IMPORTANT RESEARCH NEEDS?

*Note that the *'s above (in questions 1 and 2) indicate additional priority areas*

- Mortality and mortality implications
- Prioritize by the following *Research Identification Process*[1] *(7 points)*:
  - Delimit the ecosystem of interest and determine the physical impact changes
  - Determine the habitat use by geographic area, species and sub-stocks (life history stages) – involves time and space strata
  - Determine mortality schedules by area, species and stocks
  - Given where mortalities occur, what ecosystem processes/issues have been disrupted and what could be "restored?"
  - Based on #4 above, prioritize research projects/tasks – selected programs will define goals and objectives for work
  - Based on objectives defined in #5, determine the required monitoring and evaluation to assess those activities; define the level of confidence required in this assessment
  - Programs likely require development of sampling techniques and tools and desire to establish sampling protocols for all agencies to use; techniques need to be specific to habitat types
- Figure out how to measure salmon habitat use
- Develop accepted sampling procedures/protocols through a collaborative process
- Residence time and survival in the plume and anywhere
- Better process understanding of the linkage of restoration options to the fish benefits
- Understanding the system as a whole to make management decisions
- Defining ecosystem function
- Defining indicators and performance standards
- Look at features of the system to help predict the future:
  - Geochemistry
  - Nutrients
  - Dynamics in the estuary
  - Sediments including suspended load in restoration sites
- Inventory of restoration opportunities and another level of assessment/understanding of wetlands for prioritization (how selecting one opportunity over another?)
- Invasive species impacts
- Cross-communication between physical and biological understanding through a relational database and/or modeling

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[1] Panelist Dr. Brian Riddell of ISAB developed the *Research Identification Process to assist in prioritizing important research needs; the breakout group agreed that most of the issues raised by participants during the session would fit into Dr. Riddell's proposed process*

- Baseline monitoring
- Effectiveness studies

QUESTION 4: WHAT ARE THE MAIN CONSTRAINTS TO ACCOMPLISHING THE CRITICAL RESEARCH?

- Lack of background/baseline data for comparison
- Time and money
- Institutional barriers including an assessment of organizational mandates, opportunities for cooperation, landowner involvement, etc.
- Greater linkage needed between local efforts and research
- Staffing and coordination
- Bureaucratic hurdles including permitting
- Sampling tools and technology
- Lack of local geographic focus in local university research efforts
- Lack of method to evaluate change effectively
- Statistical confidence intervals on biological measurements are large
- Lack of program coordination in terms of marks and objectives
- Need to identify when a response is seen, i.e. large scale
- Climate change may affect restoration adversely
- Uncertainty regarding management of hydrosystem as tied to future prediction
- Lack of linkages to regulatory agency efforts
- Public opinion driving research can pose challenges
- How funding of research matches up with agency mandates is largely unknown; where are the opportunities?
- Lack of stakeholder involvement
- Modeling is limited and imperfect

APPENDIX F

Posters Displayed

Posters	
Title	**Presenter/Organization**
CHEMICAL CONTAMINANTS AND ESA-LISTED SALMON IN THE LOWER COLUMBIA RIVER	Lyndal Johnson, et al. NOAA Fisheries
COLUMBIA RIVER SALMON OFF THE WEST COAST OF BRITISH COLUMBIA AND SOUTH EAST ALASKA	M. Trudel, et al. Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, B.C., Canada
HISTORICAL CHANGES IN THE COLUMBIA RIVER ESTUARY BASED ON SEDIMENT CORES: FEASIBILITY STUDIES	James Petersen, et al.
PROLIFERATION OF NEW ZEALAND MUD SNAILS IN THE LOWER COLUMBIA RIVER	Robyn Draheim, Lower Columbia River Aquatic Nonindigenous Species Survey