Northwest Power and Conservation Council

September 10, 2009

On behalf of the Northwest Power and Conservation Council, we welcome you to the Columbia River Estuary Science and Policy Exchange.

The estuary is a new area of focus for the Council's Columbia River Basin Fish and Wildlife Program and also is recognized for its important habitat in the federal Biological Opinion on Columbia River hydropower operations. The Council supports strategies that protect, enhance, and restore critical habitat and spawning and rearing grounds in the estuary and lower Columbia River. Hydropower operations upstream change the pattern of water flows and water temperatures in the estuary and, consequently, its characteristics. However, recent scientific evidence suggests that habitat actions in the estuary have the potential to improve survival benefits for most anadromous fish populations.

The purpose of this conference is to discuss that evidence and other information and share ideas among members of the Council, scientists who are working in the estuary, and fish and wildlife managers regarding ongoing habitat restoration work and research, monitoring, and evaluation in the lower Columbia River and estuary. We hope the conference will be educational by providing a forum to identify emerging scientific issues including critical uncertainties and potential gaps in current project implementation that will inform future policy decisions, including development of the next version of the Council's Columbia River Basin Fish and Wildlife Program.

We hope you will find the conference interesting and informative and that it will be useful to you in your own work. Thank you again for attending the Columbia River Estuary Science and Policy Exchange.

Sincerely,

Joan Dukes
Council Member
Oregon

Dick Wallace
Council Member
Washington

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August 25, 2009

Northwest Power and Conservation Council
Columbia River Estuary Science-Policy Exchange

Agenda

Location: Holiday Inn-River View Room, Astoria, Oregon

Purpose: The purpose of this conference is to facilitate an exchange of information and ideas among members of the Council, the scientific community and fish and wildlife managers regarding ongoing habitat restoration work and RM&E in the lower Columbia River and estuary.

Facilitator: Donna Silverberg, DS Consultants

Day 1 -- September 10, 2009

Morning Session 8:45 to 11:45 am **Review of Ongoing Status and Trend Monitoring Efforts.**

8:45-8:55	Welcome and opening remarks -- Joan Dukes and Dick Wallace (NWPCC)
8:55-9:15	The Current State of Knowledge on How Juvenile Salmon Use the Columbia River Estuary and Plume Habitats, including a summary of the Council's 2007 Science-Policy Exchange. John Ferguson (NOAA Fisheries)
9:15-9:45	The Columbia River as a System: An Oceanographic Point of View. David Jay (PSU)
9:45-10:15	Invasive Species: Implications for Habitat Restoration and Effects on Salmonids. Mark Sytsma (PSU)
10:15--10:30	**Break**
10:30-11:00	Review of Wetland Habitat Characteristics in the Lower Columbia River and Estuary. Amy Borde (PNNL)
11:00-11:25	Survival and Behavior of Juvenile Chinook Salmon in the Lower Columbia River, Estuary and Plume. Geoffrey McMichael (PNNL)
11:25-11:45	Panel discussion wrap-up with Council members and audience.

Lunch Break 11:45 am to 1:00 pm

Afternoon Session 1:00 to 4:00 pm **Review of Research to Reduce Restoration Uncertainties.**

1:00-2:00 Toxic Contaminants and Their Effects on Resident Fish and Salmonids. Jennifer Morace (USGS), Lyndal Johnson (NOAA-F) and Elena Nilsen (USGS)

2:00-2:45 Ecological Role of Tidal-Freshwater and Tidal-Saltwater Habitats for Salmonids. Nichole Sather (PNNL) and Ed Casillas (NOAA-Fisheries)

2:45-3:00 **Break**

3:00-3:30 Development of an Ecosystem Classification System for the Columbia River Estuary. Mary Ramirez (U. of WA)

3:30-4:00 Implementing the 2008 FCRPS Biological Opinion using Emerging Scientific Tools and Restoration Strategies. Tracey Yerxa (BPA)

4:00-4:35 Review of Estuary Actions for Salmon and Steelhead Contained in the Columbia River Estuary ESA Recovery Plan Module, NOAA 2008 Biological Opinion and Council's Fish and Wildlife Program.
Phil Trask (PT&A) and Cathy Tortorici (NOAA-Fisheries)

4:35-5:00 Panel discussion wrap-up with Council members and audience.

Day 2 -- September 11, 2009

Morning Session 8:30 to 12:00 pm **Case Studies of Various Habitat Restoration Actions, Adaptive Management and Action Effectiveness Monitoring.**

8:30-9:15 Overview and Approaches to Ecosystem Restoration in the Lower Columbia River and Estuary.
Catherine Corbett (LCREP) and Ian Sinks (Columbia Land Trust)

9:15-9:45 Adaptive Management for the Ecosystem Restoration Program in the Lower Columbia River and Estuary. Blaine Ebberts (COE)

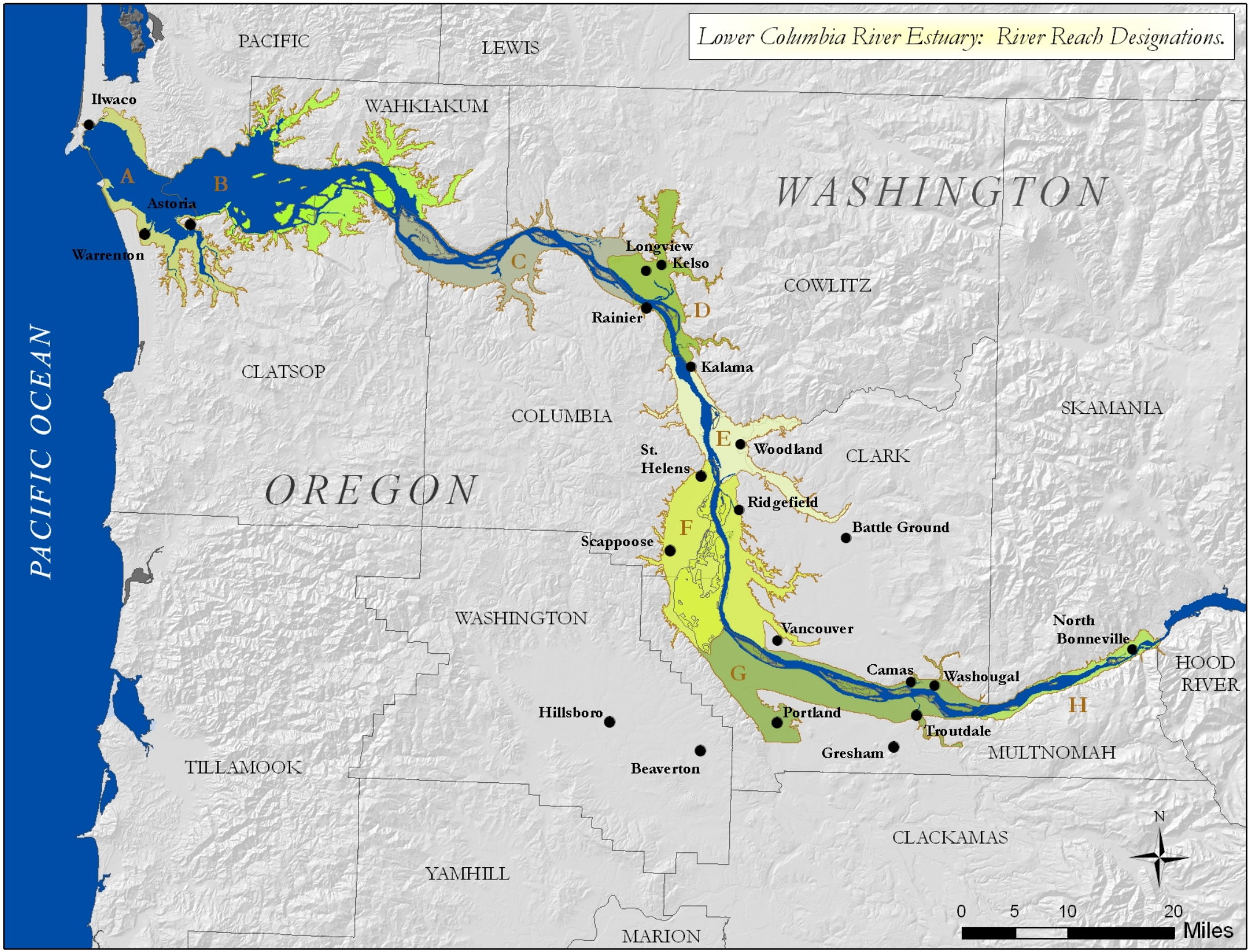
9:45-10:15 **Coffee Break**

10:15-10:45 Project-level Effectiveness Monitoring in the Estuary and Response in Fish Communities. Micah Russell (CREST)

10:45-11:15 Evaluating Cumulative Ecosystem Response of the Columbia River Estuary Ecosystem to Past and Current Restoration Efforts. Ron Thom (PNNL)

11:15-11:45 Panel discussion wrap-up with Council members and audience.

11:45-12:00 Conference summary, identification of next steps and takeaways.
Colin Levings (ISAB)


Lower Columbia River Estuary: River Reach Designations.
PACIFIC
LEWIS
WAHKIAKUM
WASHINGTON
COWLITZ
CLATSOP
COLUMBIA
SKAMANIA
CLARK
OREGON
WASHINGTON
TILLAMOOK
YAMHILL
MARION
CLACKAMAS
MULTNOMAH
HOOD RIVER
PACIFIC OCEAN
Ilwaco
Astoria
Warrenton
Longview
Kelso
Rainier
Kalama
St. Helens
Woodland
Ridgefield
Battle Ground
Scappoose
Vancouver
North Bonneville
Camas
Washougal
Portland
Troutdale
Gresham
Hillsboro
Beaverton
A
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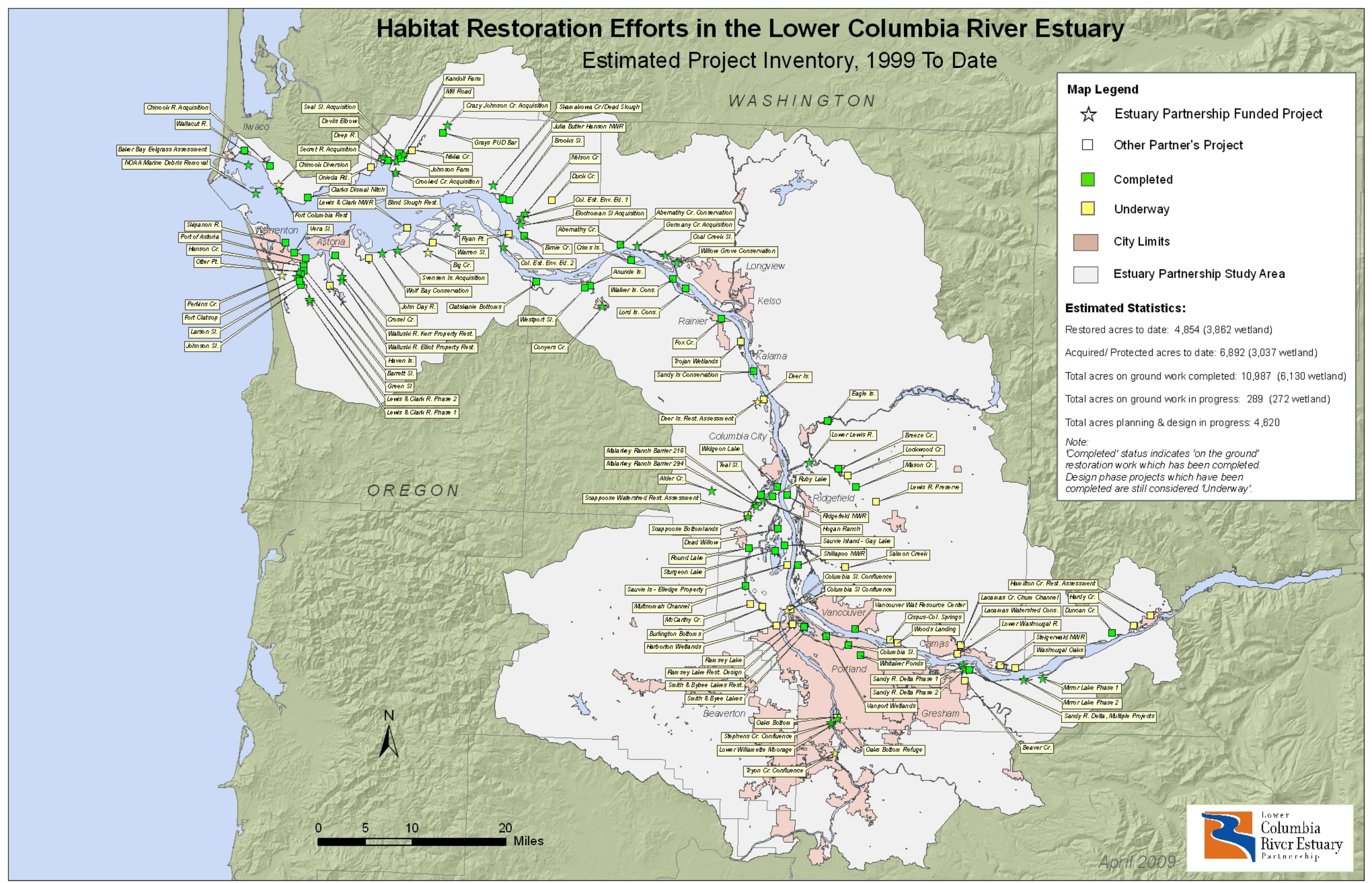
Miles

Habitat Restoration Efforts in the Lower Columbia River Estuary

Estimated Project Inventory, 1999 To Date



Map Legend

- Estuary Partnership Funded Project
- Other Partner's Project
- Completed
- Underway
- City Limits
- Estuary Partnership Study Area

Estimated Statistics:

Restored acres to date: 4,854 (3,862 wetland)

Acquired/ Protected acres to date: 6,892 (3,037 wetland)

Total acres on ground work completed: 10,987 (6,130 wetland)

Total acres on ground work in progress: 289 (272 wetland)

Total acres planning & design in progress: 4,620

Note:
'Completed' status indicates 'on the ground' restoration work which has been completed. Design phase projects which have been completed are still considered 'Underway'.

April 2009

Lower Columbia River Estuary Partnership

The Current State of Knowledge on How Juvenile Salmon Use the Columbia River Estuary and Plume Habitats

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The Council conducted an Estuary Science-Policy Exchange in September 2007. The primary conclusions from that workshop were: 1) fish from throughout the Columbia River Basin use estuary habitat for varying amounts of time before ocean entry; 2) river and estuary management should emphasize diversity (i.e., one size will not fit all) and assume there is an optimum time of residence in the estuary; and 3) policies should connect the upriver hydropower system to the lower river estuary, synthesizing available scientific knowledge in order to direct future research and policy-making (e.g., some Snake River fall Chinook are spending up to a year in the estuary). In general, these conclusions remain valid and formed the basis for updating the Council's Fish and Wildlife Program in 2009.

Since 2007, work by multiple entities has continued to identify restoration sites with the greatest potential to recover at-risk salmon stocks, under the assumption that improved performance in the estuary (i.e., feeding, growth, and survival) will promote recovery of at-risk salmon populations. Preliminary genetic data suggests that Chinook salmon stocks may not be distributed uniformly across the estuary from the mouth to Bonneville Dam, and upper Columbia River stocks appear more prevalent in upper-estuary collections. However, the majority of the restoration activities are concentrated in the lower estuary. Thus, future research activities need to focus on: 1) defining stock distributions throughout the estuary through use of synoptic surveys, 2) identifying whether salmon life history, habitat use, and performance vary by stock, and 3) assessing how increased opportunity to express life history diversity contributes to adult returns. Informing these questions will identify which restoration strategies will benefit the full diversity of Columbia River stocks and help identify the amount of restoration needed for various types of habitat and stocks. This will fulfill the requirements of the 2008 FCRPS Biological Opinion and aid salmon recovery in the basin.

In addition to these habitat use and restoration issues, key additional areas to focus on in the future include: 1) identifying why salmon smolt-to-adult rates vary with ocean entry timing (i.e., what conditions in the plume lead to improved survival that can be measured and used to adjust actions taken in freshwater (e.g., transportation, hatchery release timing, flow timing and volume?); 2) estimating the survival of adult salmon through the estuary and any potential loss to marine mammal predation; 3) determining whether contaminant loadings affect juvenile salmon growth and survival through the estuary; and 4) identifying management actions that address increased predation on juvenile salmon due to cormorants and pelicans.

The Columbia River as a System: an Oceanographic Point of View

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The Columbia River basin and associated oceanic waters present scientists and managers with a difficult problem of multiple, interacting scales. Scientists typically focus on processes and environments at a scale consonant with the analytical tools being used, and managers have defined responsibilities in specific geographic areas. In contrast, the Columbia Basin encompasses parts of seven states and two provinces in the US and Canada. The relevant "associated oceanic waters" cover a large part of the Northeast Pacific Ocean. Successfully implementing salmon recovery poses the daunting task of bringing together all the pieces to create an understanding of the system as a whole. This presentation uses field observations, remote sensing and model results to provide an overview of the physics of the system and some current issues affecting survival of juvenile salmonids, with an emphasis on processes in the estuary and coastal ocean. One of the difficulties in understanding the system is the movable nature of the functional components and habitats. For example, the Columbia plume has four components defined mainly by density contours: the lift-off zone, tidal plume, plume near-field, and plume far-field. The estuary and the tidal river are demarcated by a highly mobile boundary, the upstream limit of salinity intrusion (usually between RM-10 and RM-35), whereas tidal influence extends to Bonneville Dam. From a physical point of view, the primary forcing variables on the river basin side are the quality and quantity of river inflow at the head of the estuary, including such factors as sediment load and temperature. The primary forcing variables on the oceanic side are the tides and coastal circulation properties. The tides at the mouth of the estuary, the tidal response of the river, riverine and sediment inputs, and river water temperature all exhibit trends that impact vital habitats (or the ability of juvenile salmonids to use those habitats) in the fluvial, estuarine and coastal parts of the system. Changes in flow and tides, along with diking, have drastically reduced shallow water habitat area (SWHA) below Bonneville Dam.

Invasive Species: Implications for Habitat Restoration and Effects on Salmonids

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Abstract not available at press time.

Review of Wetland Habitat Characteristics in the Lower Columbia River and Estuary

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Shallow water habitat in the lower Columbia River and estuary (LCRE) is diverse and varies longitudinally along the main stem and laterally away from the main stem as tidal amplitude decreases and overall land elevation increases. However, the extent of these habitats is limited and has been modified from historic coverage due to changes in land use practices and modified river flows. We have monitored biological and morphological aspects of wetland habitat structure throughout the lower Columbia River and estuary as part of numerous programs designed to evaluate status and trends, to provide a means of evaluating restoration actions, and to improve restoration design. Our underlying goal of this research is to provide indicators of ecosystem processes such as macrodetritus input, nutrient cycling, and maintenance of biodiversity. Additionally, evaluating habitat structure and hydrologic patterns provides a means of evaluating the potential use by salmonids. For example, the potential for site access by juvenile salmonids is linked to the morphology of wetland channels and the inundation regime. Further, the type of vegetation present may affect the types of prey resources and the quality of cover for refuge. Additional research is needed to solidify the links between habitat structure and function in the LCRE; however evaluating the characteristics of these shallow water habitat types is a first step in understanding the potential for these ecosystems to provide critical functions.

The types of vegetated shallow water habitat in the LCRE can be divided into four broad categories: submerged aquatic vegetation (SAV), emergent marshes, shrub scrub, and forested wetlands. Within the LCRE, these habitats vary depending on location within the landscape and dominant hydrologic influence (tidal or riverine). Submerged aquatic vegetation is present throughout the estuary in shallow water areas; limited in distribution by the extent of the photic zone at the lower edge and desiccation at the upper limit. At the mouth of the estuary a marine SAV species is present: *Zostera marina*. *Z. marina*, known commonly as eelgrass, occurs throughout the world and is known to provide important habitat for many juvenile fish species. In the LCRE we have been evaluating the distribution, factors controlling survival, and potential for restoration of eelgrass. Preliminary results indicate the species may have been more abundant historically and is now recruitment-limited, suggesting restoration may be a successful means of increasing this limited habitat. Emergent marshes have also been shown to be important rearing and refuge areas for juvenile fish species world-wide. In the LCRE these habitats have been degraded or disconnected from tidal flows throughout the estuary. The elevation range of native vegetation species, channel morphology, and inundation frequency changes depending on the hydrogeomorphic location of the marsh in the estuary. Knowing the range in these controlling factors required by the wetland species will help ensure restoration success for these habitats.

Tidal shrub scrub systems are a successional stage between emergent marshes and forested systems and may provide benefits to salmon based on their cover and inundation regime, however further research is needed in this under studied system. Tidally influenced Sitka spruce

(*Picea sitchensis*) swamps in the lower estuary (below river mile 40) have become relatively rare habitats and are not well-studied in the Northwest. However, the prevalence of tidally influenced spruce swamps in the LCRE historically suggests this habitat may be an important niche for salmonids. Recent research has shown that topographic heterogeneity and a complex structure of large wood in tidal channels are critical components of these systems. Tidally influenced riparian forested systems dominated by cottonwood (*Populus balsamifera*) and Oregon ash (*Fraxinus latifolia*) are found above river mile 40 in the estuary. This is a dominant habitat type on islands and is found along undisturbed stretches of mainland beaches and tributaries. The age of these systems appears to be one factor influencing the habitat structure, however further research comparing sites of different ages is necessary.

In general, a mosaic of habitat diversity is critical for any functioning ecosystem, regardless of scale. In the LCRE, all shallow water habitats are significantly limited in spatial cover and distribution compared to historical conditions, therefore salmon habitat improvement in the estuary should focus on restoration of a mosaic of shallow water habitat types to increase existing habitat diversity.

Survival and Behavior of Juvenile Chinook Salmon in the Lower Columbia River, Estuary and Plume

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The survival of juvenile Chinook salmon in the lower 235 km of the Columbia River and estuary, between Bonneville Dam and the Pacific Ocean, has been monitored since 2005 using JSATS miniaturized acoustic transmitters and autonomous receivers. Results from 2005 and 2006 showed higher than expected losses in the lower Columbia River and estuary (LCRE) downstream of the Federal Columbia River Power System (FCRPS). Using receiver arrays to partition the LCRE during studies from 2007 through 2008 has revealed that the greatest loss of emigrant Chinook salmon smolts occurs in the lower portion (50 km) of the LCRE. Based on previous findings, 2009 efforts focused primarily on the lower 50 km of the LCRE. Yearling Chinook salmon tended to travel the 235 km between Bonneville Dam and the mouth of the river in about 4 days, with later groups traveling faster than fish released earlier. Subyearling Chinook salmon traveled more slowly, making the trip in 4 to 5 days. Both stocks slowed their migration speed considerably upon reaching the 'wide part' of the estuary (around river km (rkm) 50), especially subyearling Chinook salmon. Juvenile Chinook salmon used both main channel and off-channel habitats during their migration through the LCRE. Larger proportions of the subyearling Chinook salmon (36%) were detected in off-channel areas in comparison to their yearling counterparts (29%). Most of the juvenile Chinook salmon pass the Caspian tern and double-crested cormorant colonies relatively near East Sand Island, where the majority of the nesting takes place. The estimates of avian predation account for only a small portion (~10%) of the estimated loss of JSATS-tagged fish in the LCRE. Preliminary estimates for yearling Chinook salmon survival in 2009 showed approximately 90% survival from Bonneville Dam to Harrington Point at rkm 50, with sharp declines to the next two arrays at Astoria Bridge (rkm 22; 84% survival) and East Sand Island (rkm 8; 76% survival). Subyearling Chinook salmon survival was also lowest in the final 50 km of the river in 2008, though they survived at a higher rate than the yearling fish, with an estimated 89% surviving to East Sand Island (rkm 8). Later (after first week in July) migrating subyearling Chinook however, had very low apparent survival in most years (30-45%). During 2008, a short-term test of three JSATS receivers in the Columbia River plume resulted in detections of 72 tagged fish and showed that travel rate decreased three-fold upon ocean entry. Future plans for monitoring behavior and survival of juvenile salmon downstream of the FCRPS call for close integration with assessment of BiOp performance standards for survival at the lower three FCRPS dams and other proposed research in the estuary and plume. The monitoring capability that has been developed around JSATS technology can be applied and extended to assess the success of FCRPS mitigation strategies and other management actions in the LCRE and plume.

Toxic Contaminants and Their Effects on Resident Fish and Salmonids

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Toxic contaminants are present in the Columbia River Basin. One byproduct of advances in modern chemistry is the accumulation of synthetic chemicals in the natural environment. These compounds include contaminants that have been around for years—DDT and other agricultural pesticides, PCBs, and PAHs—as well as contaminants that are "new" on the scene—PBDE flame retardants, industrial byproducts, and pharmaceuticals and personal care products. Some of these "emerging" contaminants are endocrine disrupting compounds that can have detrimental reproductive effects in wildlife and humans. Results from several studies will detail which compounds have been detected in water and bed sediments of the lower Columbia River and estuary.

Resident and anadromous fish utilizing these ecosystems are exposed to toxic contaminants and their health is being compromised. Recent studies showed that levels of PCBs, DDTs, and PAHs in bodies and stomach contents of outmigrant juvenile salmon from the Lower Columbia were often above thresholds for effects on salmon health, such as delayed mortality, poor growth, and reduced disease resistance. Moreover, concentrations of copper and pesticides in the water column were at levels that could interfere with olfaction in salmon at some sites. Population models suggest that these toxicant –related impacts on juvenile salmon fitness and survival could impact stock recovery. Wastewater compounds and other contaminants of emerging concern may be a problem as well. In a study of resident largescale suckers, fish tissues are being analyzed to identify where and to what extent these classes of compounds are bioaccumulating in resident fish of the Columbia River. These results will contribute to understanding whether bioaccumulation of selected compounds is occurring in resident fish of the Columbia River. Information on the biological impacts of these emerging classes of contaminants is vitally necessary to ensure proper management of important resources.

Urban and industrialized areas in the lower Columbia River are source areas for toxic contaminants for multiple fish stocks. Genetic analyses show that juvenile fall Chinook salmon from upper, middle, and lower Columbia stocks are feeding and rearing in the estuary, and are exposed to PCBs, DDTs, PBDEs and PAHs at this time. The Portland/Vancouver area is an especially important major source of exposure for all fall Chinook stocks. Salmon from the Portland sites also showed signs of exposure to estrogenic compounds. Water-column data collected using passive samplers support these findings as well.

A better understanding of the sources and pathways of toxic contaminants is needed to develop reduction efforts and restore fish and ecosystem health. Information is especially needed about toxic loadings coming from wastewater-treatment plant effluents and stormwater runoff, which may be sources of "emerging contaminants" such as pharmaceuticals and PBDEs, as well as other chemicals of concern. A recent study sampled these sources and pathways throughout the basin from Wenatchee to Longview, and analyzed for wastewater-indicator compounds, pharmaceuticals, PCBs, PBDEs, and estrogenicity. This fall, stormwater runoff from the same cites will be analyzed for a slightly different set of contaminants—PCBs, PBDEs, PAHs, metals, currently used pesticides, and oil and grease. These two pathways are poorly understood in terms of their toxic contribution to the system and offer an area where changes could be made to lessen human impact on the environment.

Juvenile Salmon Ecology in the Lower Columbia River and Estuary: Tidal Freshwater Research

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A holistic knowledge and understanding of salmon ecology in the Columbia River Basin is fundamental to recovery of salmon stocks. Until recently, information pertaining to the ecology of juvenile salmon in tidal freshwater habitats in the Columbia River had been limited. Our research centers on two fundamental questions: 1) In what types of habitats within the tidal freshwater area of the Columbia River are juvenile salmonids found, when are they present, and under what environmental conditions? 2) What is the ecological contribution of shallow (0–5 m) tidal freshwater habitats to the recovery of ESA-listed salmonids in the Columbia Basin? This research, performed under the auspices of the NW Power and Conservation Council's Fish and Wildlife Program (Project No. 2005-001-00), is a collaborative effort among the Pacific Northwest National Laboratory, the Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, and the University of Washington. The base study area for field research, initiated in 2007, has been the vicinity of the Sandy River delta (Rkm 190-202). In 2009, the study area was expanded to include sample sites in tidal freshwater habitats between Longview, WA and St. Helens, OR (Rkm 109-141). Physical and habitat data are collected concurrently with beach seine data to serve as covariates in a fish/habitat analysis.

Our research to date has resulted in several key findings with regard to habitat use of tidal freshwater habitats by specific genetic salmon stocks, habitat restoration, and implications of interactions between non-native species and juvenile salmon. Juvenile salmon are present in a diversity of shallow tidal freshwater habitats throughout the year. Chinook salmon encountered within our study area included many genetic stock groups; however, the majority of samples included Chinook salmon from the Upper Columbia River summer/fall stock group. Dissolved oxygen and water elevation data indicate restoration in the form of reestablishing connectivity between habitats may increase accessibility to juvenile salmon as well as improving water quality conditions in degraded habitats. In addition, we determined that 46% of the resident fish community within shallow tidal freshwater habitats sampled was comprised of non-native taxa. Results of our diet analysis on Chinook and coho salmon and the putative diets of non-native fishes, coupled with the consistent spatial and temporal overlap in occurrence of non-native species and salmonids suggest inter-specific resource competition between introduced fishes and native salmon may occur at our sites. This research is filling data gaps concerning the distribution of distinct genetic stocks of juvenile salmon, food habits of Chinook and coho salmon, and fish community structure within tidal fresh water habitats in the Lower Columbia River and estuary. As we continue to build our dataset on salmon ecology in tidal freshwater habitats, we are reducing uncertainties associated critical life stages of juvenile salmon, thus contributing to informed management decisions about restoration in the lower Columbia River. Future collaborative research efforts will continue to focus on assessing the early life history characteristics of juvenile salmon in a diversity of shallow tidal freshwater environments, and to link salmon ecology to habitat restoration and recovery of threatened and endangered salmonids in the Columbia River basin.

Ecological Role of Tidal Saltwater Habitat for Salmonids

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We report on the ecological role of tidal saltwater habitat for salmonids by describing the historical and contemporary variations in juvenile Chinook salmon life histories, habitat associations, and food webs in the Columbia River estuary. Chinook salmon occur at near-shore estuary beach seining sites during all months of the year, increasing in abundance from January through late spring or early summer and declining to a lower but persistent level after July. Recently emerged fry begin dispersing throughout the estuary in early spring, and fry migrants were abundant in the estuary until at least August each year. Small (< 70mm) Chinook salmon were among the most abundant species in all wetland habitat types (emergent, forested, and scrub-shrub) surveyed in the lower 100 km of the estuary. During each spring, mean sizes of salmon increased from the tidal freshwater zone to the estuary mouth and may reflect estuarine growth and continued entry of smaller individuals from upriver. Studies of prey availability and salmon diets indicate that tidal wetlands are a major source of prey for juvenile Chinook salmon both within and outside wetland habitats. Insects produced in wetlands and other shallow habitats were dominantly utilized by salmon throughout the estuary, including larger size classes of fish that do not typically reside in wetland channels. Estimated growth rates of juvenile Chinook salmon derived from otolith analysis averaged 0.5 mm^{-1} day, comparable to rates reported for juvenile salmon in other Northwest estuaries. Estuarine salmon collections were composed of representatives from a diversity of lower and upper Columbia Basin ESUs. Genetic stock groups in the estuary exhibited distinct seasonal and temporal abundance patterns.

Wetland losses have not only reduced availability of shallow peripheral rearing habitats but also have eliminated an important carbon source for salmonid food webs. Stable isotope analyses indicate that contemporary salmon select disproportionately for food webs linked to vascular plants and benthic diatoms, most likely through their consumption of prey resources produced in wetlands and other shallow-water habitats. These results suggest that reduced sources of macrodetritus from removal of tidal wetlands could undermine the estuary's capacity to support juvenile salmon. Together, changes throughout the basin (e.g., hatchery programs, population losses, flow regulation) and in the estuary (e.g. wetland habitat losses, increased water temperatures) may have decreased the proportion of Chinook salmon using the estuary during summer and fall months compared with the patterns observed during the first salmon life history study in 1916. These results support the hypothesis that life history diversity of Columbia River salmon has diminished since early in the twentieth century and could limit the resilience of salmon populations to future environmental change.

Development of an Ecosystem Classification System for the Columbia River Estuary

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Systematic approaches to understanding the organization of highly variable and dynamic ecosystems often rely on classification and stratification of their hydrogeomorphic structure for both a conceptual and statistical framework. To better support research, monitoring, restoration, preservation, and other planning and management activities in the Columbia River estuary, we sought a hierarchical framework that would facilitate delineation of the diverse ecosystems and component landscape structures along the 233-km estuarine gradient from the ocean entrance to the base of Bonneville Dam. Review of the few existing approaches to classifying large river, tidal freshwater surge plain and estuarine ecosystems such as in the Columbia River estuary indicated that none effectively addressed tidal-freshwater ecosystems or were of sufficiently fine resolution to include geomorphic structure at the scales we needed to discriminate juvenile salmon habitat and other features of interest. Accordingly, we designed the Columbia River Estuary Ecosystem Classification System ("Classification") to aggregate tidal surge plain, wetland and aquatic cover classes according to the ecosystem processes that structure landscape attributes at different spatial scales. The Classification is based on six levels, progressing from the coarsest, regional scale to the finest, localized scale: (1) Ecosystem Province; (2) Ecoregion; (3) Hydrogeomorphic Reach; (4) Ecosystem Complex; (5) Geomorphic Catena; and, (6) Primary Cover Class. Of the six hierarchical levels, the Ecosystem Complex and Geomorphic Catena levels are based on unique GIS analyses of bathymetric, geologic, geomorphic and biological attributes and potentially provide the most informative metrics of variable ecosystem state and biotic habitat structure applicable for research, monitoring and conservation planning. In particular, the geomorphic catena may prescribe some of the more diagnostic features of juvenile salmon habitat and the variability in landscape organization across the estuary. In describing the Classification, we focus on examples of these two levels for one hydrogeomorphic reach; we are currently acquiring the necessary datasets in order to complete the Classification for the remainder of the estuary, expected to be complete summer 2011.

Implementing the 2008 FCRPS Biological Opinion using Emerging Scientific Tools and Restoration Strategies

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Restoration and protection actions in the Columbia River estuary are an important component of the 2008 Biological Opinion of Federal Columbia River Power System Operations (2008 BiOp). To implement these actions in a much more strategic and expedient approach, the Action Agencies have increased funding for project implementation and expanded the type of projects implemented. Applied research and monitoring is being re-focused and existing data is being synthesized to help guide restoration efforts. Existing and emerging restoration/preservation tools are being tested and evaluated to provide coordination and implementation entities such as the Estuary Partnership, Columbia Land Trust, CREST, watershed councils, and conservation districts the guidance they need to build projects that meet goals in the 2008 BiOp, the Estuary Recovery Plan Module, and watershed-scale plans.

The Columbia River Estuarine Ecosystem Classification (ECY) is an emerging restoration tool that will improve monitoring efforts and help guide restoration actions in the estuary. ECY is being developed by Bonneville Power Administration through the University of Washington, US Geological Survey, and the Estuary Partnership, When completed, ECY will provide an ecosystem classification that uses geology, topography, bathymetry, and land cover to categorize the unique features of the estuary, and particularly those determined to be important habitats of juvenile salmonids. The ECY is a hierarchical classification that partitions the estuary into different ecosystem classes at six levels, where Levels 3-5 (Hydrogeomorphic Reach, Ecosystem Complex, Geomorphic Catena) are most applicable to our 2008 BiOp planning needs.

Currently there is a demonstration project in one of the eight hydrogeomorphic reaches to examine relationships among ECY classes and emerging salmonid genetics data from the Northwest Fisheries Science Center. Researchers are conducting a peer-reviewed analysis to use the genetics information about the 13 Evolutionarily Significant Units (ESUs) in the Columbia River basin to make inferences about the types of estuarine habitats used uniquely by the ESUs and different life history types among them. Based on these inferences, ecological principles and rules will be proposed to help focus the types and locations of the most effective restoration/preservation actions. Estuary restoration implementers in the region will provide practical on-the-ground knowledge to identify for implementation priority project sites that best fit the principles/rules objectives. In combination with all the other restoration/preservation actions taking place in the estuary, these strategic actions are designed to knit together a more connected, productive mosaic of juvenile salmon habitats that specifically meets ESU recovery needs.

Review of Estuary Actions for Salmon and Steelhead Contained in the Columbia River Estuary ESA Recovery Plan Module, NOAA 2008 Biological Opinion and Northwest Power and Conservation Council's Fish and Wildlife Program

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The National Marine Fisheries Service (NMFS), in conjunction with the Bonneville Power Administration and the Army Corps of Engineers, the Northwest Power and Conservation Council, and other regional stakeholders are working together to implement an integrated program for estuary habitat restoration, conservation, research, monitoring and adaptive management. Since 2000, major program actions have occurred including the release of NMFS' 2008 Biological Opinion for the Federal Columbia River Hydropower System, the development of the Columbia River Estuary Recovery Plan Module for Salmon and Steelhead (Estuary Module), and the Northwest Power and Conservation Council's 2009 Lower Columbia River and Estuary Program, all of which focus on survival and recovery of Endangered Species Act (ESA)-listed stocks of salmon and steelhead in the Columbia River Basin.

The NMFS's 2008 Biological Opinion builds on Reasonable and Prudent Alternative actions beginning in 2000 to include seven actions specific to estuary habitat restoration (RPA 36, 37, and 38), survival improvement targets (RPA 37), and monitoring and research (58, 59, 60, and 61). Actions 36, 37, and 38 require the Action Agencies to identify and implement high quality restoration projects that will meet the survival improvement targets set forth in the 2008 Biological Opinion. Actions 58 and 60 focus on estuary and plume monitoring. Action 59 emphasizes the development of and ecological classification system for estuary habitats. Action 61 emphasizes the life cycle of salmon and steelhead through research focused on the Columbia River plume and ocean.

The Estuary Module is a plan to help improve estuary survival for ESA-listed stocks of salmon and steelhead in the Columbia River Basin. Development of the plan began in 2005 by the Lower Columbia River Estuary Partnership for NMFS. It identifies limiting factors and their underlying causes (threats) to provide a basis for 23 management actions designed to improve conditions for salmonids during their residency in the estuary and plume environments. The management actions are evaluated for how well the actions reduce key threats. Each action is further evaluated for cost, schedule, and likely implementer. The Estuary Module also includes a chapter detailing an approach to monitoring, research, and evaluation to help reduce uncertainties and guide future restoration efforts. The Estuary Module is expected to be completed in fall of 2009 and will be incorporated by reference into all Columbia River Basin salmon and steelhead recovery plans.

Northwest Power and Conservation Council's 2009 Lower Columbia River and Estuary Program emphasizes use of the Columbia River Estuary and Lower Columbia subbasin plans and the Estuary Module to guide actions in the estuary and lower Columbia River. The Council's program supports strategies that protect, enhance, and restore critical habitat and spawning and rearing grounds in the estuary and lower Columbia River.

Overview and Approaches to Ecosystem Restoration in the Lower Columbia River and Estuary

Catherine Corbett[1] and Ian Sinks[2]

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The Lower Columbia River Estuary Partnership with key partners such as the Columbia Land Trust, Columbia River Estuary Study Taskforce, watershed councils and others, has developed an ecosystem restoration approach with an overarching goal of implementing well coordinated, scientifically sound projects restoring tidal wetlands and other key aquatic habitats. This presentation will provide an overview of the ecosystem restoration approach at two different scales—the larger programmatic scale and the individual project scale. On the programmatic level, several efforts will be reviewed that are characterizing ecosystem status, developing a system of reference sites, and evaluating the effectiveness of individual restoration actions. These programs include the ecosystem monitoring project, action effectiveness monitoring, reference sites, and the cumulative effects of restoration. The programs in combination will result in integral information to further prioritize locations and refine methods for future habitat restoration and protection actions in the lower river. Having this regional coordination allows for consistency in restoration goals and in assessment methods so that program success can be evaluated over time and throughout the entire lower river. On the project level, the presentation will review examples of the types of restoration projects currently used to achieve restoration ecosystem structure and function; the steps needed to complete individual projects; and the invaluable lessons learned within each step from over a decade of concerted habitat restoration and protection efforts involving numerous partners.

Adaptive Management for the Ecosystem Restoration Program in the Lower Columbia River and Estuary

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Ecosystem restoration in the lower Columbia River and estuary is beginning to evolve towards a regional effort. However, with federal, state, Tribal and non-governmental entities involved in the funding, planning, and execution of restoration actions sound scientific guidance is lacking from an adaptive management approach. With the reality of limited funding, the planning, implementation and monitoring of restoration projects must be efficient. Projects exhibiting the highest probability of being successful, and which directly target the goals for restoration programs while minimizing cost, must be given the highest priority for implementation. However, even with the highest priority projects there are uncertainties. Hence, it is important to monitor the effectiveness of these projects in meeting their goals and to learn from them in order to improve future projects. Under programs funded by the Corps of Engineers, Bonneville Power Administration through the Lower Columbia River Estuary Partnership, and others, a framework to improve decision-making for ecosystem restoration is emerging. This framework emerged as an integral component of an assessment of the cumulative response to ecosystem restoration within the lower Columbia River and estuary. Because of limitations for monitoring within Corps ecosystem restoration programs the outline of this framework needed to adhere specifically to Corps institutional requirements. Additionally, the framework needed to be transparent and all inclusive making a smooth transition from Corps centric to regionally applicable. The framework draws on a set of building blocks including an ecosystem-based approach to habitat restoration projects; extensive research on salmonid use of shallow water habitats in the lower estuary; a conceptual model; a set of monitoring protocols; a research program on assessing the cumulative effects of restoration projects on the ecosystem; a reference site characterization study; and, a habitat monitoring program. Taken as a whole, these building blocks provide a strong set of the key elements to improve decision-making on what, where and how to restore habitats. The emerging framework draws upon each of these elements in an integrated manner, while being grounded in the realities of what agencies can implement within existing jurisdictions.

Project-level Effectiveness Monitoring in the Estuary and Response in Fish Communities

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CREST is very active in environmental planning, habitat restoration and effectiveness monitoring in the Columbia River Estuary. Utilizing grant funds, and contracts with other agencies and academic institutions, CREST biologists and wetland specialists collect data at a variety of locations throughout the estuary to assess the ecological impact of restoration projects, particularly juvenile salmonid use of restored wetlands. Using standardized methods developed for the region through the US Army Corps "Cumulative Effects" Study, CREST gathers pre- and post-project, as well as reference site, data on hydrology, water quality, sedimentation, vegetation and fish communities. Field data on salmonids is augmented with laboratory analysis of prey utilization, prey availability and genetic stock. In accordance with Action Effectiveness Monitoring requirements in the 2008 Biological Opinion, CREST participates in the Estuary Partnership led program to develop intensive long-term datasets at four restoration sites in different reaches (Fort Clatsop, Scappoose Bottomlands, Sandy River Delta and Mirror Lake), whereas monitoring of other projects is less consistent according to the availability of funding. This presentation will present an overview of lessons learned, and policy implications, from juvenile salmon effectiveness monitoring in Grays Bay, WA and Youngs Bay, OR.

Evaluating Cumulative Ecosystem Response of the Columbia River Estuary Ecosystem to Past and Current Restoration Efforts

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If ecosystem restoration is to continue to be pursued, we need to know if restoration efforts are effective in meeting their goals. In the Columbia River estuary (CRE), there are three basic questions relative to the effectiveness of restoration, as follows: 1) Are individual projects meeting their local performance objectives? 2) Is the multitude of efforts adding up to produce an improvement in the broader estuarine ecosystem? 3) Are the local and cumulative ecosystem improvements helping salmon? Obviously, the complexity and uncertainty associated with answers to these questions increases as one moves from question #1 to question #3, as does the importance of the answer relative to salmon in the CRE.

An ecosystem-based approach for restoration was developed in 2003, which formed the basis for a framework employed since 2007 to prioritize proposed restoration projects. The prioritization framework is under further development to improve its ability to incorporate the latest science to better inform decisions based on issues such as which genetic stocks most benefit from estuarine habitats. A reference site program and habitat monitoring program are underway, which both help in the design of projects as well as assess factors contributing to natural variation in project outcomes. Finally, there is a draft adaptive management plan for ecosystem restoration that can be used to capture learning, and inform plans for new restoration projects and conservation actions. This plan is also effective in capturing results of new research findings and immediately putting those findings into action.

Over the past five to 10 years or so, the focus has grown on the estuary as a place where salmon populations could benefit from restoration. There is a developing suite of activities that, when taken together, form the genesis of an integrated estuarine restoration program that should have direct benefits to salmonid populations. These activities include:

- Studies providing the scientific underpinnings of the role of estuarine habitats in supporting early-life history stages of salmon,
- Technologies to track the movement of very young salmon,
- Site specific studies on salmon occurrence and feeding in restored systems,
- Studies on changes in factors that salmon respond to such as temperature, and prey production and availability in restored systems,
- Development of a framework to quantify the role of the cumulative effect of restored sites on the broader estuary ecosystem and salmon.

The goal of the Corps-funded research during 2004-2009 was to develop and begin to implement an evaluation of the cumulative effects of multiple habitat restoration actions in the lower Columbia River and estuary. Because we could find no studies that

explicitly attempted to assess cumulative effects of restoration projects on an ecosystem benefitting fish, we developed a "levels of evidence" approach. In this approach, field-collected and modeled data are analyzed additively for net ecosystem improvement; hydrodynamic model outputs and meta-analyses are examined for synergistic effects; and predictive ecological relationships between structure and function are developed relative to hydrology, vegetation, and fish. Synthesis of these three lines of evidence forms the basis for the cumulative effects evaluation. The program requires input from multiple projects and practitioners in the system. Thus, to facilitate comparison of monitoring data across restoration projects, we established a protocols manual for standardized monitoring of physical and biological metrics. Monitored indicators include water depth and temperature, channel geometry, vegetation and elevation surveys, above-ground biomass, fish species composition and abundance. During 2005 through 2009 field studies, baseline and post-restoration data were collected on restoration sites and associated reference sites, including brackish marsh and tidal freshwater swamp habitats that have sustained substantial areal losses due to flood control, hydropower and water withdrawals. Information on the cumulative effects of ecosystem restoration actions will provide the Region with predictive capabilities to help design the best projects to meet program goals, as well as highlight uncertainties and ways to modify approaches within an adaptive framework.

As an example from our research, we examined linear and synergistic relationships in dike-breach restoration scenarios on the tidal portion of the Grays River, a tributary of the Columbia River estuary. The purpose was to improve the efficacy of suites of projects designed to provide habitat for endangered anadromous fishes. We used data from a hydrodynamic model to test the hypothesis that the cluster size of hydrological reconnection projects has a nonlinear effect on the area of floodplain inundation and available habitat, under both even and uneven spatial configuration scenarios.

Findings and products to date developed in the cumulative effects studies are:

1. An estuary-wide habitat monitoring protocol that can be used by all restoration projects to collect similar data sets on their performance
2. Proof of frequent and prolonged juvenile salmonid use of restored systems
3. Proof of salmonid prey production in restored systems
4. Evidence of improved water quality (i.e., lower temperature) in restored systems
5. Evidence of production and export of marsh macrodetritus from the restored systems to the broader estuary (thus restoring a major process lost over the past century)
6. Evidence of initiation of nutrient processing and dissolved organic matter export from restored systems
7. Evidence of reformation of natural tidal channel morphology
8. Evidence of resumption of sediment accretion process to enhance the rate of habitat recovery
9. Data indicating the rate of habitat change is rapid over the first five years for emergent wetland systems, but full recovery of tidal forest swamps will take many decades

10. Establishment of full tidal hydrology reconnection is generally more effective than muted reconnection
11. Development of a method to predict cumulative effects now and in the future
12. Modeling proof of potential synergistic effects and optimization of multiple restoration projects on wetted area
13. Development of a draft adaptive management plan for ecosystem restoration in the CRE.

At the recent National Conference on Ecosystem Restoration, the CRE was listed as among the top seven or eight ecosystem-based restoration programs in the country. The CRE program is under scrutiny by the Chief of the USACE as well as the Office of Management and Budget, and the Administration. The message from the Administration through OMB is that programs that are both ready and 'good' will receive continued funding. The rarely stated working hypothesis is "restoring historical, and conserving existing, shallow water habitats and landscapes will result in the increased fitness and survival of young salmon and thus increase salmon populations." In smaller systems it has been demonstrated that restoring the ecosystem components that salmon utilize does benefit populations. However, the scale of the CRE is large and complex making the resolution of the response of salmon populations to multiple small actions difficult. To resolve the response requires:

- A more concentrated and coordinated effort which includes effectiveness monitoring of restored sites,
- Quantification of the realized function of these sites to young salmon,
- Monitoring of adult returns in a strategic manner, and
- Focused, feasible adaptive management to validate and improve predictive models and thus maximize the effectiveness of future efforts, and produce 'good' projects worthy of continued investment.

There is an opportunity for the CRE to demonstrate to the country how ecosystem restoration can successfully and efficiently recover endangered species.

Columbia River Estuary Science-Policy Exchange
Speaker Profiles

John Ferguson – NOOA Fisheries NFSC – Dr. Ferguson is the Director of the Fish Ecology Division and oversees research conducted in the five programs within the Division. Dr. Ferguson's primary expertise lies in evaluating means to improve the condition and survival of fish passing through spillways, bypass systems, and turbines at dams in regulated rivers. His recent interests include 1) modeling the effects of passing dams on fish populations, 2) the behavior of juvenile Atlantic salmon and sea trout during downstream migrations, 3) the role habitat complexity has on salmonid life history diversity expression, 4) the potential impact of wave energy development on coastal ecosystems and marine resources, and 5) the potential impact of climate variability on freshwater and marine ecosystems and salmonid productivity in the Pacific Northwest.

David Jay – Portland State University – Dr. Jay is Professor of Civil and Environmental Engineering at Portland State University. He conducts research on a variety of estuarine, coastal and tidal related topics including estuarine circulation and salinity intrusion, buoyant plume processes and human alteration of coastal environments. He is researching the effects of man and nature have on salmon habitat in the Columbia River basin. He is working to establish the Center for Columbia Basin Research at Portland State.

Mark Sytsma – Portland State University – Dr. Sytsma is an Associate Professor of Environmental Sciences director of the Center for Lakes and Reservoirs, and co-director of the Aquatic Bioinvasion Research and Policy Institute. He co-authored the Oregon Aquatic Invasive Species Management Plan and is responsible for implementation of the Plan in collaboration with other state agencies. He is a founding member of the Oregon Invasive Species Council, the Columbia River Basin Team of the 100th Meridian Initiative, and the Western Regional Panel on Aquatic Nuisance Species.

Amy Borde – Pacific Northwest National Laboratory – Ms. Borde specializes in wetland ecology and restoration. She has conducted an assessment of eelgrass meadows in Puget Sound and Northwest coastal estuaries, the development of innovative methods of propagating and transplanting seagrass and an assessment of areas proposed for mitigation. Ms. Borde has recently been involved in national studies on innovative coastal habitat restoration, the ecological functions and societal values of isolated wetlands, and issues related to wetland mitigation banks.

Geoff McMichael – Pacific Northwest National Laboratory - Mr. McMichael received his bachelor's and master's degrees in Fish and Wildlife Management at Montana State University in Bozeman and has spent the past 20 years studying Pacific salmon in the northwest. He is a Senior Research Scientist in the Ecology Group at the Pacific Northwest National Laboratory in Richland, Washington. He has managed several acoustic telemetry projects using the newly-developed Juvenile Salmon Acoustic

Telemetry System (JSATS) over the past six years. His recent research has focused on juvenile salmonid behavior and survival through the lower Columbia River and estuary as well as extended rearing juvenile fall Chinook salmon in the Snake River. He is the JSATS Coordinator for PNNL.

Jennifer Morace – US Geological Survey - Jennifer Morace is a hydrologist with the U.S. Geological Survey (USGS), Oregon Water Science Center. She is a graduate of Oregon Health Sciences University (M.S., 1996, Environmental Science and Engineering). She has been with USGS since 1991 and has worked on many water-quality studies in the Columbia, Willamette, Yakima, and Klamath basins. Her current work and interests focus on evaluating water-quality conditions in the Columbia River Basin, particularly "toxics"--pesticides, legacy compounds, pharmaceuticals, wastewater compounds, PBDEs, and emerging contaminants.

Lyndal Johnson – NOAA Fisheries NFSC – Ms. Johnson is a zoologist in the Ecotoxicology and Environmental Fish Health Program of the Environmental Conservation Division. She joined the Division in 1984 as part of the fish pathology team, and studied chemical contaminants and fish disease as part of NOAA's National Benthic Surveillance Program. As the leader of the Ecological Assessment Team in the Ecotoxicology and Environmental Fish Health Program, Lyndal is currently working with the Lower Columbia River Estuary Partnership, USGS, and other agencies to study effects of chemical contaminants on juvenile salmon in the Lower Columbia River, and with Washington State Department of Fish and Wildlife and the Puget Sound Ambient Monitoring Program to survey Puget Sound bottomfish and salmon for exposure to environmental estrogens. Lyndal has also been involved in recent evaluations of water and sediment quality standards for their utility in protecting listed salmon and other fish species, and provides technical guidance to resource managers on how to protect marine animals from harmful impacts of toxicants.

Elena Nilsen – US Geological Survey – Dr. Nilsen joined the USGS in 2004 from the University of California, Santa Cruz, where she worked on issues of carbon cycling, nutrient dynamics, and anthropogenic impacts on estuarine ecosystems. She was a Mendenhall Post-doctoral Fellow with the USGS Coastal and Marine Geology Program in Menlo Park, CA, studying impacts of contamination on estuarine ecology and geochemistry. She continues as a research chemist at the Oregon Water Science Center in Portland where she works on issues related to emerging contaminants in the Columbia River Basin.

Nichole Sather – Pacific Northwest National Laboratory - Ms. Nichole Sather is a fisheries ecologist with the Coastal Assessment and Restoration technical group at the Pacific Northwest National Laboratory. Ms. Sather's project work includes wetland and coastal habitat assessments, research development in fishery ecology, as well as NEPA reviews and preparation of environmental impact statements as an aquatic ecology subject matter expert. Ms. Sather has extensive field experience working in estuarine, nearshore, and freshwater environments. Her research at the Pacific Northwest National

Laboratory has primarily focused on the ecological relationship between juvenile salmon and estuarine and nearshore habitats.

Ed Casillas – NOAA Fisheries NFSC – Dr. Casillas has worked for NOAA Fisheries for more than 20 years. He has evaluated the effect of human use of toxic compounds in coastal environments on marine fishes, invertebrates and salmon, and the role of natural climate change on growth and survival of juvenile salmon in the estuarine and coastal marine environments of the Pacific Northwest. As Program Manager of the Estuary and Ocean Ecology Program, Ed's responsibilities are to supervise the program's research activities, which fall into three principal areas: defining the role of estuaries for salmon and how they function to benefit completion of the salmon life cycle, defining the role of the Columbia River plume as an important early ocean habitat for juvenile salmon and participating in the Northeast Pacific Global Ocean Ecosystems (GLOBEC) projects. GLOBEC brings together NOAA and academic scientists to assess the relationship between physical and biological processes (including salmon) in the coastal region of Northern California and Southern Oregon.

Mary Ramirez – University of Washington – Mary Ramirez is a research analyst with the Wetland Ecosystem Team at the University of Washington. She received an M.S. from the School of Aquatic and Fishery Sciences, University of Washington.

Tracey Yerxa – Bonneville Power Administration – Tracy is a Contract Officer Technical Representative with Bonneville focusing on the Columbia River estuary. Prior to joining BPA she worked for the US Bureau of Reclamation in the Yakima basin for the Yakima River Basin Water Enhancement Project.

Phil Trask – PC Trask and Associates – Before forming his own consulting firm, Phil worked for Washington's Lower Columbia Fish Recovery Board to create the Lower Columbia and Estuary Subbasin Plans and the LCFRB's Salmon Recovery Plan for the Washington side of Lower Columbia tributaries and estuary. He helped develop the Columbia River Estuary ESA Recovery Plan Module for NOAA. His firm specializes in developing habitat restoration projects and ecosystem planning.. He formerly served as a Board Member for the Lower Columbia River Estuary Partnership.

Cathy Tortorici – NOAA Fisheries - Cathy Tortorici is the Branch Chief for the Oregon Coast/Lower Columbia River Branch of NOAA Fisheries in Portland, Oregon. She has B.S. and M.S. degrees in Biology. She received a M.S. in Entomology from the University of Kansas in 1985. Cathy's responsibilities include restoration, regulation, research, and monitoring activities at local and regional scales of coastal systems, including the Columbia River estuary.

Catherine Corbett – Lower Columbia River Estuary Partnership – Catherine Corbett serves as Technical Program Manager for the Lower Columbia River Estuary Partnership. Prior to joining LCREP in 2008, Catherine was Senior Scientist for the Charlotte Harbor National Estuary Program located in Ft. Meyers, Florida.

Ian Sinks – Columbia Land Trust - Ian Sinks is the Stewardship Manager for the Columbia Land Trust in Vancouver, Washington. The Columbia Land Trust is a private, non-profit organization dedicated to working with willing landowners to conserve important habitats and landscapes within the lower Columbia River region. Ian is responsible for both land acquisition and stewardship of conserved lands. One of his current focus areas is working with partners and community members to protect and restore intertidal habitats within the lower Columbia River and estuary.

Blaine Ebberts – US Army Corps of Engineers – For the last eighteen years Blaine Ebberts worked for the US Army Corps of Engineers, Portland District in fish passage at large hydroelectric facilities and ecosystem restoration in the lower Columbia River and estuary. Prior to coming to the Corps Blaine worked as a research fisheries biologist for NMFS in Alaska and a biologist at the National Marine Mammal Laboratory in Seattle Washington. Prior to becoming a "real" biologist Blaine worked for Greenpeace saving whales. Blaine has a BS from Oregon State University in Biology with an emphasis in Marine Biology.

Micah Russell – Columbia River Estuary Study Taskforce – Micah is the Director of the Columbia River Estuary Study Taskforce. He administers and directs the activities of CREST on behalf of member cities, counties and ports in the region: environmental planning and management, habitat restoration and assessment, and estuarine research and monitoring. Micah works closely with partner agencies, universities and non-profits in striving to further CREST's mission and offer valuable services to the community. With expertise in coastal/estuarine ecology and fisheries, he is uniquely suited to oversee and implement CREST's research and monitoring programs, in addition to his directorial duties.

Ron Thom - – Pacific Northwest National Laboratory – Dr. Thom leads the Coastal Assessment and Restoration technical group at the Marine Sciences laboratory in Sequim, WA. He has conducted research in coastal and estuarine ecosystems since 1971. His research includes habitat construction and restoration; adaptive management of restored systems; effects of pollution; benthic primary production; climate change; and ecology of fisheries resources.

Colin Levings – Independent Scientific Advisory Board – Dr. Levings is an Adjunct Professor at the Institute for Resources, Environment and Sustainability and an Honourary Research Associate in the Department of Zoology at UBC. He has published over 200 scientific papers, conference proceedings papers, technical reports, and books including the co-editorship of a definitive volume on fjord oceanography. Although he has specialized in salmon and estuarine ecosystems, he has also worked on benthic ecology in fjords, discovered chinook wintering rearing habitat in the upper Fraser River, researched off channel habitat use by juvenile chinook and coho in Fraser River tributaries, initiated the first studies on Canada's Pacific coast on ballast water as a pathway for exotic species, and published papers on marine protected areas and coastal biodiversity, critical habitat, habitat mapping and GIS methodology, climate change and

other topics. Colin has conducted applied studies on estuary and river habitat disruption, marine riparian ecology, estuarine habitat restoration, pollution from pulp mills, sewage, oil spills, ocean dumping and dredging, wood waste and log booms, acid mine drainage, and fish farms.

Columbia River Basin Fish and Wildlife Program
Projects currently funded by the Bonneville Power Administration in the Columbia Estuary/Lower Columbia River

Project summaries

Title: Evaluate Sturgeon Populations in the Lower Columbia River
Project Number: 1986-050-00
Sponsor: Oregon Department of Fish and Wildlife (ODFW).
Summary: This project includes a series of closely coordinated and complementary activities being implemented in an orderly progression from initial problem scoping to full-scale restoration and mitigation in the Columbia River downstream from Lake Roosevelt, and in the Snake River downstream from Lower Granite Dam. The project has evolved from conducting research on white sturgeon in the Columbia River Basin to implementing mitigation activities based on research results, and monitoring the effects of mitigation activities.

Title: Select Area Fisheries Enhancement
Number: 1993-060-00
Sponsor: Oregon Department of Fish and Wildlife (ODFW).
Summary: As part of the 1993 Strategy for Salmon, the Northwest Power and Conservation Council recommended terminal-fishing sites be developed to allow harvest of known hatchery production while minimizing incidental harvest of weak stocks. Beginning in 1991, listing of various ESU's under the federal ESA complicated harvest management and severely limited execution of mixed-stock fisheries in the mainstem Columbia River. The Select Area Fisheries Evaluation (SAFE) Project was subsequently initiated by Bonneville Power Administration (BPA) in 1993 to mitigate fisheries by providing the opportunity to harvest locally-produced salmon stocks in off-channel areas of the Columbia River. Based on evaluations and given available funding, five Select Area fishing areas were established and four currently exist including Youngs Bay, Tongue Point/South Channel, and Blind Slough/Knappa Slough in Oregon and Deep River in Washington. Approximately 4,000,000 coho, spring, and fall chinook hatchery smolts are currently reared and released from SAFE net pens and associated hatcheries. Commercial and recreational fisheries have expanded substantially due to improved rearing strategies and increased releases as the project has progressed from research to implementation. Potential for additional expansion of the SAFE Project exists with the current infrastructure and is primarily constrained by available funding.

Title: Ocean Survival of Salmonids
Number: 1998-014-00
Sponsor: National Oceanic and Atmospheric Administration (NOAA)
Summary: The project's recent work in the plume and adjacent coastal zone has shown that the northern California Current may have experienced another regime shift, beginning in late 1998. Due in large part to increases in the length of the upwelling season in 1999, zooplankton biomass has doubled in the coastal waters off Oregon, community composition has shifted to a dominance of cold water species, and salmon survival has increased five-fold. Therefore, it is important to keep in mind that the plume and plume dynamics are modulated by climate

influences at decadal scales as well as inter-annual, seasonal and daily scales depending upon the strength of the upwelling process. Thus, plume-ocean interactions are a key component of the research program.

Title: Evaluate Spawning of Fall Chinook and Chum Salmon Just Below the Four Lowermost Mainstem Dams
Number: 1999-003-01
Sponsor: Oregon Department of Fish and Wildlife (ODFW).
Summary: This project determines what conditions must exist to provide successful spawning and rearing below lower Columbia River mainstem dams and what measures must be taken to protect those fish. Specifically, this project describes the abundance, spatial and temporal distributions, and stock origins of spawning chum and fall Chinook salmon, as well as the emergence timing and emigration from local rearing areas. In addition, it identifies operational and physical habitat factors affecting spawning.

Title: Sandy River Delta Habitat
Number: 1999-025-00
Sponsor: US Forest Service (USFS).
Summary: Sandy River Delta was historically a wooded, riparian wetland with components of ponds, sloughs, bottomland woodland, oak woodland, prairie, and low and high elevation floodplain. It has been greatly altered by past agricultural practices and the Columbia River hydropower system. The original channel of the Sandy River was diked in the 1930's, and diverted into the "Little Sandy River". The original Sandy River channel has subsequently filled in and largely become a slough. Restoration of historic landscape components is a primary goal for this land, with current focus on restoration of riparian forest and wetlands. The Forest Service proposes to remove the 1930's dike across the Sandy River to restore the hydrologic pattern and improve estuary habitat for anadromous fish. Restoration of open upland areas (meadow/prairie) would follow substantial completion of the riparian and wetland restoration.

Title: Reintroduction of Chum in Duncan Creek
Number: 2001-053-00
Sponsor: Pacific States Marine Fisheries Commission (PSMFC).
Summary: Duncan Creek was a historically important spawning area for chum salmon, estimated returns of 500 adults annually. A three-pronged approach is being used to reestablish a self-sustaining chum salmon population in Duncan Creek. First, the original dam structure (built in 1963) was replaced in 2000 to provide dual usage of the area, a lake from June 1 through October 15 and a pre-impoundment configuration providing access to and from salmonid spawning grounds (creek and spawning channels) from October 16 to May 31. Second, spawning channels were constructed in fall of 2001. Channels are located in historical chum salmon spawning areas with natural springs/seeps providing the water. Third, beginning fall of 2001, and occurring annually since, chum salmon brood stock have been collected from nearby spawning areas and used in supplementation programs at Duncan Creek. Three methods of reintroduction are being evaluated: natural straying from adjacent spawning populations, direct adult supplementation into the spawning channels above monitoring weirs, and fed-fry supplementation releases via artificial propagation. An intensive and comprehensive monitoring and evaluation program is associated with the supplementation program. Fry resulting from

supplementation methods are marked allowing statistical comparison of adult returns and fry-to-adult survival rates between the two artificial reintroduction methods. The success of this habitat as a spawning refugia is evaluated by egg-to-fry and fry-to-adult survival rates and monitoring a variety of physical parameters in the channels. This proposal seeks to continue brood stock collection for supplementation, and if deemed necessary a salvage operation, and the monitoring and evaluation associated with these activities. Results from this project will provide the background and framework to successfully implement other chum salmon reintroduction projects in the Lower Columbia River domain.

Title: Estuary/Ocean Research, Monitoring and Evaluation (RM&E) Support
Number: 2002-077-00
Sponsor: Pacific Northwest National Laboratory (PNNL)
Summary: The goal of this project is to facilitate the estuary/ocean subgroup (EOS) and related activities for federal research, monitoring, and evaluation (RME) in the lower Columbia River, estuary, and ocean and to aid the action agencies in certain aspects of implementation of the 2008 Biological Opinion (BiOp) on Operation of the Federal Columbia River Power System. Comprehensive RME by the Action Agencies was mandated in the 2008 BiOp. The federal RME process is ongoing and includes the EOS, whose members include the Action Agencies, the Estuary Partnership, NMFS, and PNNL. A major milestone for the EOS was completion of the Estuary RME Program document in January 2008. The framework and many of the elements from the Estuary RME Program were built into the BiOp and vice versa.

This scope of work covers five estuary/ocean RME topics during FY09. First, the EOS will facilitate and document the federal estuary RME effort. . Second, address the BiOp's RPA 37 (NMFS 2008) by working cooperatively with the Action Agencies to establish a regional technical group and convene periodic meetings to assess survival benefits from estuarine habitat restoration. Third, convene and annual coordination of estuary/ocean RME participants to assure efficiency, avoid redundancy, and share results for their common good,. Fourth, support for federal RME efforts regionally coordinated through the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), an assemblage of federal, state, and tribal agencies whose goal is "…to coordinate important scientific information at the appropriate scales needed to inform public policy and resource management decisions." And, fifth, EOS input into federal basin-wide RME through the Technical/Policy Oversight Group

Title: Lower Columbia River Estuary Ecosystem Monitoring
Number: 2003-007-00
Sponsor: Lower Columbia River Estuary Partnership (LCREP).
Summary: This project creates a consistent approach to protocol development and status and trends monitoring of estuarine habitats. The goal is to develop an ecosystem based monitoring program focused on increasing the survival of juvenile salmonids The Estuary Partnership in conjunction with USGS will provide dissolved oxygen, temperature, and conductivity data at habitat and fish monitoring locations. USGS will develop a summary report documenting the results of the sampling that will be included in the Estuary Partnership' s Year 5 annual report.

Title: Historic Habitat Food Web Link
Number: 2003-010-00
Sponsor: National Oceanic and Atmospheric Administration (NOAA).

Summary: This proposal addresses specific information needs identified in a recent interdisciplinary assessment of the hydroelectric system's impacts on estuarine habitat conditions for juvenile salmon. The goal of this research is to reconstruct historic changes in estuarine rearing opportunities and food web linkages of Columbia River salmon and to evaluate their implications for managing river flows and restoring estuarine habitats.

Title: Columbia River Estuary Habitat Restoration
Number: 2003-011-00
Sponsor: Lower Columbia River Estuary Partnership (LCREP).
Summary: The mission of the Lower Columbia River Estuary Partnership' s Habitat Restoration Program is to implement and monitor strategic, well-coordinated, scientifically sound projects designed to rehabilitate, enhance, protect, conserve, create, and restore 16,000 acres tidal wetlands and other key habitats to support native species using the Lower Columbia River estuary from the river's mouth to Bonneville Dam, with a special emphasis on ESA listed species, and other focal species described in the Comprehensive Conservation Management Plan and the sub-basin plan.

Title: Grays River Watershed Assessment
Number: 2003-013-00
Sponsor: Pacific Northwest National Laboratory (PNNL).
Summary: The Pacific Northwest National Laboratory (PNNL) is collaborating with the Columbia River Estuary Task Force (CREST) on implementation of the Grays River Restoration Project (BPA Project 200301300). The Grays River is vitally important to the recovery of Lower Columbia River (LCR) chum salmon because it currently has the most viable population remaining in the LCR region. The Grays River watershed is also important to the recovery of salmon and steelhead in the LCR ecosystem. Today, numbers of naturally spawning salmon and steelhead have declined to levels far below historical numbers because of habitat limiting factors that include but are not limited to the lack of habitat connectivity, diversity, channel stability, riparian function and altered stream flow conditions. The long-term objective of this project is to restore habitat-forming processes to enhance salmon and steelhead populations in the Grays River, following recommendations developed during the FY04-06 BPA-sponsored Grays River Watershed Assessment (BPA Project # 2003-013-00). Specifically, this project will be the first step in restoring channel structure and function that will increase instream habitat diversity, channel stability, and riparian integrity in the critical response reach upstream and adjacent to critical salmon spawning areas of the Grays River.

Title: Tidal Freshwater Monitoring
Number: 2005-001-00
Sponsor: Pacific Northwest National Laboratory (PNNL).
Summary: This study will 1) provide basic data on the migration characteristics and ecology of yearling and subyearling salmonids in tidal freshwater habitats in the vicinity of the Sandy River delta in the lower Columbia River; and 2) assess feasibility to apply acoustic telemetry technology for action effectiveness research and quantify residence times and migration pathways in shallow, tidal freshwater habitats. The Sandy River delta and vicinity was chosen as the study area because it is in the tidal freshwater area of interest (RM 110-146), there is a major habitat restoration project ongoing there with potential for significant restoration of shallow

water habitat for juvenile salmonids, the area was mandated in the Action Agencies' Implementation Plan for the Updated Proposed Action, and because of relatively high mortality rates below Bonneville Dam. Research on juvenile salmonid ecology in tidal freshwater is also called for in the Northwest Power and Conservation Council's Lower Columbia Subbasin Plan and draft Research Plan. The project proposes to use a shallow (0-2 m) beach seine to sample fish within three of the most common shallow tidal freshwater habitats: river confluence floodplain, shallows, and mainstem islands. This is not a pilot study for an estuary-wide research, monitoring, and evaluation program. The study will perform status and trends monitoring and uncertainties research on yearling and subyearling salmonids in tidal freshwater and develop protocols for action effectiveness research.

Title: Impact of American Shad in the Columbia River
Number: 2007-275-00
Sponsor: US Geological Survey (USGS)
Summary: American shad (Alosa sapidissima) are non-native anadromous clupeids that have become extremely abundant in the Columbia River during the last 70 years, with adult counts at Bonneville Dam being as high as 5 million fish during recent years. American shad adults, perhaps over 20 million, enter the lower Columbia River during April-June for spawning. Juveniles outmigrate in vast numbers primarily during July through early winter, and evidence suggests that many overwinter in the estuary. However, there is very little known about their potential positive or negative impacts on the aquatic community.

The goal of this project is to provide credible lines of argument regarding whether shad provide positive benefits or are detrimental to efforts to restore Columbia River fisheries. This project will provide information on the role that juvenile and adult shad play as competitors for forage, as forage themselves, and as potential vectors of disease that may influence the productivity of salmonid populations. While little is known about American shad in the Columbia River, this project will build upon extensive research from the east coast of North America where efforts to restore American shad runs to rivers have been underway for decades. The project includes coordinated activities to address three objectives; 1) shad as potential competitors of juvenile salmon for forage, 2) the role that shad play as prey for juvenile salmon (a potential positive effect) and as prey supporting growth of native and introduced predators of juvenile salmon (a potential negative effect), and 3) the role that shad may play as vectors of disease that poses a potential threat to the restoration of salmonid populations. Field, laboratory, and modeling tasks will begin in 2007 and will continue through 2009.

Title: Removal of Sea Lions at Bonneville Dam
Number: 2008-003-00
Sponsors: Oregon Department Of Fish and Wildlife (ODFW)
Idaho Department of Fish and Game (IDFG)
Pacific States Marine Fisheries Commission (PSMFC)
Washington Department of Fish and Wildlife (WDFW)
Summary: The sponsors, PSMFC, ODFW, WDFW, and IDFG propose to construct and operate California sea lion trapping equipment to mark, monitor, haze, and facilitate the removal of California sea lions preying on fishes at Bonneville Dam.

Title: Sea Lion Non-Lethal Hazing
Number: 2008-004-00
Sponsor: Columbia River Inter-Tribal Fish Commission (CRITFC)
Summary: Sea lion presence below Bonneville Dam was rare and their consumption of salmonids was not a major concern prior to the 2000 Biological Opinion for Operation of the Federal Columbia River Power System (FCRPS) (NMFS 2000). Since 2001, the ACOE have been documenting sea lion abundance and estimating predation rates using visual observations within a quarter mile of the dam. Currently, the only quantitative measure of sea lion predation in the Columbia River is the ACOE limited observation area below Bonneville Dam, however, the amount of predation in the lower 150 miles is unknown and estimated through modeling at 13,000 in 2007 (http://wdfw.wa.gov/wlm/sealions/sec_120_appl.pdf). Boat-based hazing activities in 2007, reported that approximately one-quarter of all hazing events involved a predation observation (Brown et al. 2007). Boat hazers reported a total of 1,494 hazing events and salmonid predation was observed in every site within the study area (Navigation Marker 85 to Bonneville Dam approximately 6 miles). This confirmed that substantial sea lion predation is occurring beyond of the observation limit (area viewable from the tailrace deck of the Dam) of the ACOE's enumeration program and necessitates the need for a technique to estimate sea lion predation. The Pinniped Fisheries Interaction Task Force expressed the desire for more data on sea lion abundance, distribution, and predation in the Columbia River (NOAA 2007b) and this project seeks to gather that data. .

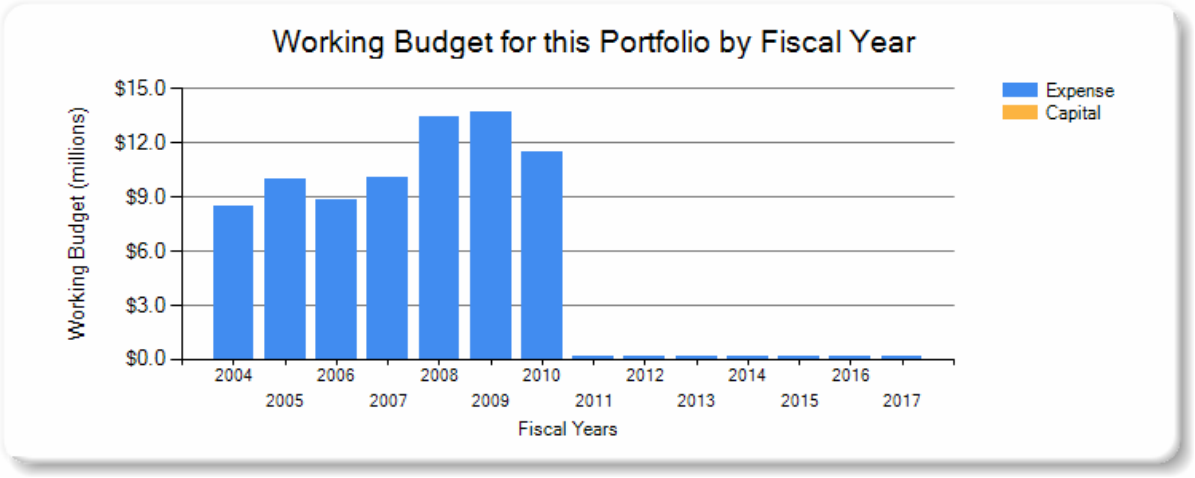
Title: Development of an integrated strategy for Chum salmon restoration in the tributaries below Bonneville Dam.
Number: 2008-710-00
Sponsor: Washington Department of Fish and Wildlife (WDFW)
Summary: Chum Salmon Restoration in the Lower Columbia River – Development of an Integrated Strategy to Implement Habitat Restoration, Reintroduction and Hatchery Supplementation in the Tributaries below Bonneville Dam. (WDFW)
WDFW's proposed chum restoration approach for LCR chum salmon is as follows:
Step 1. Determine if remnant populations of chum salmon exist in LCR tributaries.
Step 2. if such populations exist, develop stock-specific recovery plans involving habitat restoration that include the creation of spawning refugias, supplementation where necessary, and a habitat and fish monitoring and evaluation plan. Step 3. if chum salmon have been extirpated from previously utilized streams, develop reintroduction plans that utilize appropriate genetic donor stock(s) of LCR chum salmon, and integrate habitat improvement and fry-to-adult survival evaluations.

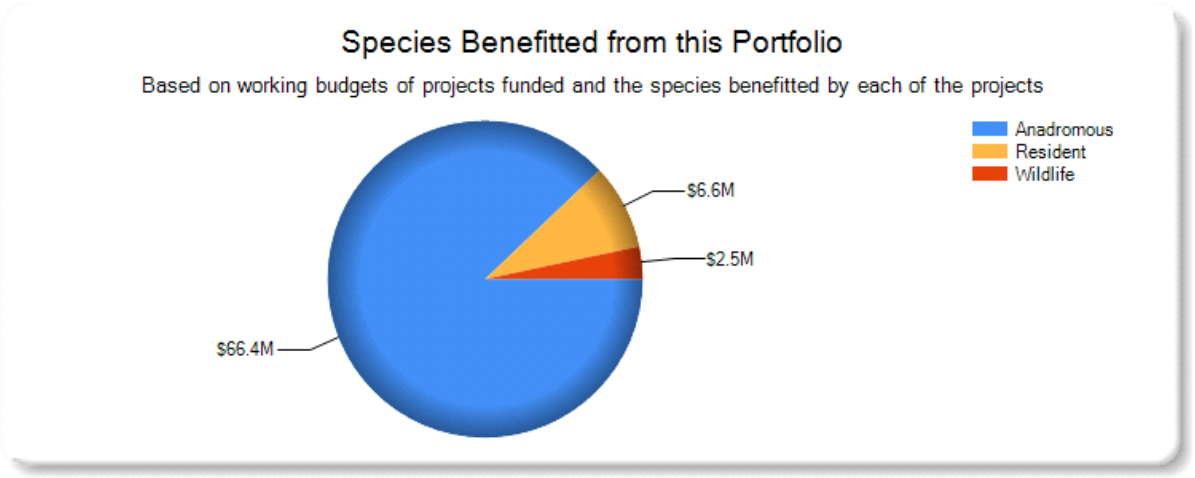
Innovative projects - limited performance period:

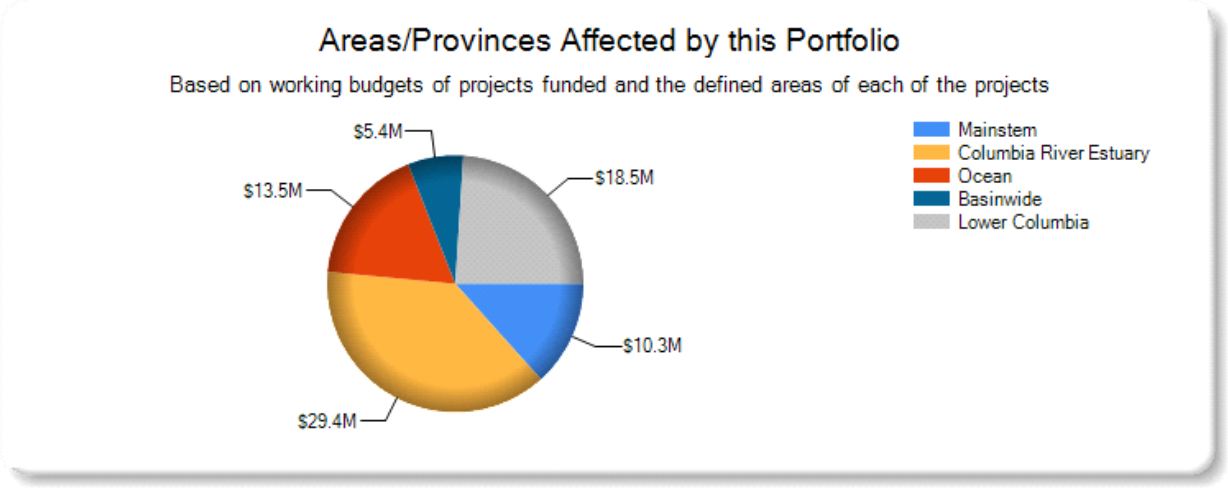
Title: Eelgrass Enhancement and Restoration
Number: 2007-513-00
Sponsor: Pacific Northwest National Laboratory (PNNL)
Summary: Strong flows in the Columbia River likely limit the success of eelgrass seed dispersal and new plant establishment. This project will use innovative site selection techniques to identify 5-10 areas suitable for eelgrass enhancement, plant eelgrass and monitor success.

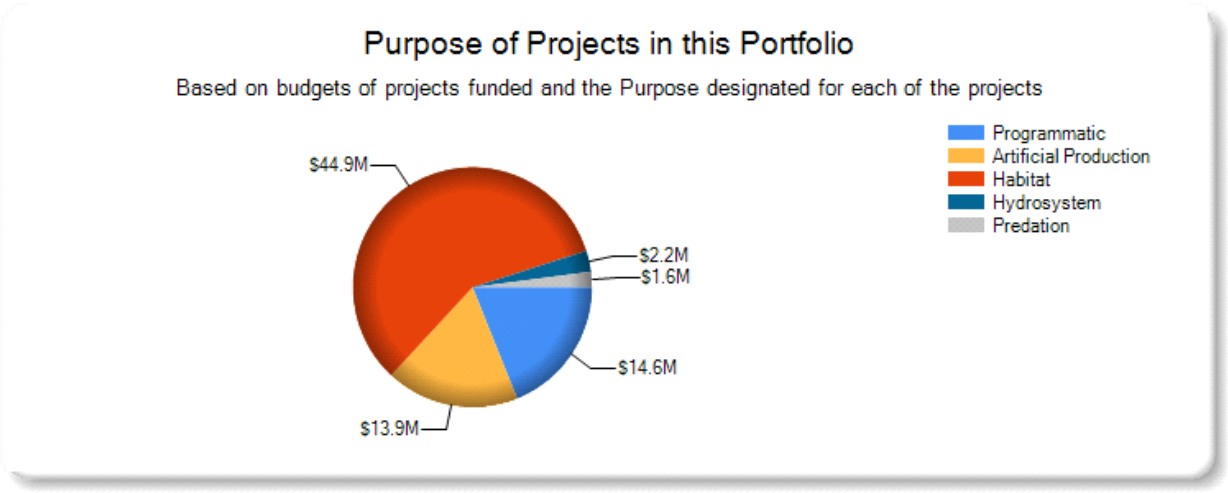
Title: Integrated Non-Lethal Electric Barrier Sea Lion Abatement
Number: 2007-524-00
Sponsor: Smith-Root, Inc.
Summary: The scope of this contract is to develop and implement a demonstration project to assess the potential to deter upstream movement and predation by marine mammals on Columbia Basin fish resources. The objective is to deploy and evaluate a passive, integrated electric barrier and sonar array that selectively inhibits upstream marine mammal movements and predation, without injuring pinnipeds or affecting anadromous fish migrations. A combined split-beam, broadband sonar system will be integrated with a electric grid using protocols that detect, classify and track marine mammals, and activate an electrical field only when pinnipeds are present.

Summary of projects listed above:









*****Project summary information and charts provided by Taurus and Pisces (Bonneville Power Administration.

Related projects (not included in summary charts above):

Number: 2003-114-00
Title: Pacific Ocean Survey Tracking (POST)
Sponsor: Kintama Research
Summary: Kintama Research is working to construct an ocean tracking array for measuring the movements and survival of fish as small as salmon smolts along the west coast of North America & establish the relevance of such a tool for addressing important resource management issues, in particular, to develop the assessment of early marine survival and ocean movements for Columbia River salmon stocks. In 2006, the project began direct measurements of the survival of Snake & Yakima River run-of-river (ROR) spring chinook smolts, and also compared the relative survival and performance of transported vs ROR Snake R smolts.

This project seeks to provide objective information as to where Columbia River Chinook salmon smolts migrate to in the sea, and key information on the rates of marine mortality during the initial phase of the marine life cycle. These data will be used in an explicit test of the PATH hypothesis that delayed mortality due to the hydrosystem is the cause of the problem, and secondly will be used to assess the efficacy of transport to boost salmon returns. Successful demonstration of the application of the array to Columbia River salmon recovery issues would address a number of key RPAs which existing approaches cannot adequately address. Given the record salmon returns to the Columbia River in several years since the ocean climate changes of 1999, a critical issue for successful salmon management is to distinguish the true effects on salmon returns caused by the operation of the hydrosystem from those due to ocean climate change. The POST (Pacific Ocean Shelf Tracking) array is designed to be able to separate marine from freshwater impacts on salmon, and to localize the regions of the coast where mortality is high.

Number: 2003-009-00
Title: Canada-USA Shelf Salmon Survival Study
Sponsor: Canada Department of Fisheries and Oceans
Summary: The primary objective of this research is to assess the effects of ocean conditions on the production of Columbia River Basin salmon. The information generated in this study is intended to map the ocean conditions that determine the growth and survival of Pacific salmon along the west coast of North America from southern British Columbia to southeast Alaska, and to identify which stocks of Columbia River salmon forage in these areas. Documenting the extent of changes in growth, along with changes in physical features of the ocean will help to improve our understanding of how climatic events in the ocean can impact important fish resources. More specifically, the samples collected in this study will provide an assessment of whether different stock groups (including ESA listed stocks) predominate in regions of poor growth and survival. This research will also provide baseline data that can be used to forecast the size of Columbia River salmon runs.

Projects currently funded by the Corps of Engineers in the Columbia Estuary/Lower Columbia River

Project summaries

Title: A Study of Salmonid Survival and Behavior through the Columbia River Estuary Using Acoustic Tags
Sponsor: NMFS/ PNNL
Summary: Recent evidence suggests that improvement in survival of the estuarine and early ocean life history phase of Columbia River salmon may be critical to the recovery of endangered stocks. Survival success of Columbia River salmon hinges on the complex interaction of smolt quality and the abiotic and biotic ocean conditions at the time of entry and during their first year of ocean residence. Factors that potentially affect age-class recruitment during the first months of ocean residency include fish size and health status at the time of entry, entry timing, and ocean conditions during the first months. These factors are influenced or controlled by several aspects of the Columbia River estuary: differences in life history strategies, river flow (hydropower system management), and estuarine habitat availability and quality. Therefore, it is important to understand how salmonids use the estuary, both spatially and temporally, and how different ESU's, life history types, and various rearing, passage, and condition histories use and benefit from the estuary, and how these conditions affect ocean entry timing and survival. The development of micro-acoustic transmitters enables their use in the lower Columbia River and estuary environment for both ocean- and stream-type salmon.
Objectives:
1. Estimate survival from Bonneville Dam through at least five river reaches to the mouth of the Columbia River for yearling and subyearling Chinook salmon, and possibly steelhead.
2. Quantify the effects of FCRPS passage history on mortality of emigrant juvenile yearling and subyearling Chinook downstream of Bonneville Dam; compare survival for spill, RSW, JBS, and turbine passage. For each release replicate calculate and compare mortality rates between treatment groups.
3. Monitor and map estuary migration pathway and habitat associations and behaviors relative to these pathways to support estuary habitat restoration activities.
4. Determine the fate of subyearling Chinook salmon that ceases migration in the Columbia River downstream of Bonneville Dam.
5. Determine over-winter survival of subyearling Chinook who cease migration in the lower river and estuary.
6. Estimate survival probabilities for yearling and subyearling Chinook salmon within the plume.
7. Competitively procure prototypes of "rearing Chinook" acoustic micro-transmitters for function and biocompatibility evaluation.

Title: Estuarine Habitat and Juvenile Salmon – Current and Historic Linkages in the Lower Columbia River and Estuary
Sponsor: NMFS
Summary: Studies completed to date reveal that the Columbia River estuary 1) is used by juvenile salmonids all year long, 2) is used by juvenile salmon representative of all ESU's, 3) that shallow water habitats associated with marsh and forested wetlands are used by smaller

juvenile salmon of each ESU whereas larger juveniles use the larger order channels, 4) residence time for juveniles salmon averages 21 days in wetland habitats that contribute to their growth and survival, 5) that insects represent a major food source and source of energy for juvenile salmon, and 6) insects are associated with vegetated wetland sites. The focus of the information is generated from the mouth of the Columbia River to RM 40. Although Chinook salmon stocks from the lower Columbia River dominate this reach, it is hypothesized that tidally influenced habitat from RM 40 to Bonneville Dam will be used to a greater extent by mid and upper Columbia basin salmon stocks in a similar manner. However, this is unknown and needs to be verified.
Objectives:
1. Evaluate the diversity and importance of life history strategies used by juvenile salmonids from RM 40 to Bonneville Dam
2. Evaluate salmon prey resources and performance (e.g., growth, foraging success) at representative locations in the tidally influenced portion of the lower Columbia River
3. Determine habitat-specific rearing patterns among different source populations (ESU's) in the Columbia River estuary from RM 40 to Bonneville Dam.

Title: Evaluation of the Relationship among Time of Ocean Entry, Physical, and Biological Characteristics of the Estuary and Plume Environment and Adult Return Rates
Sponsor: NMFS
Summary: The goal of this study will be to examine the relationship among time of salmonid ocean entry, physical and biological characteristics of the Columbia River estuary and near shore plume environment, and smolt-to adult return rates (SARs) for yearling chinook and/or coho salmon. The last release of juvenile emigrants occurred in 2006, this work will focus on adult return rates and the analysis of physical and biological features measured when juveniles were released. While this program has potential management purposes more suited to the hatchery, harvest, and transportation programs than specific estuarine studies, the Portland District feels this data coupled with outside funding (BPA and NMFS) of estuary and near shore/plume habitats biological and physical characteristics is too valuable and important NOT to continue for the cost.

Title: Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the Lower Columbia River and Estuary
Sponsor: PNNL/ NMFS/ CREST/UW
Summary: The types of estuarine restoration being implemented in the LCRE by the Corps and others include activities to: (1) reconnect backwater channels, sloughs and oxbows and recover estuarine wetlands through dike removal and tide gate replacement; (2) reconnect upland drainages and freshwater inflow through removal of armored channels, culverts, diversions, and other channelizing structures; (3) remove intertidal fills and piling fields; (4) allow natural accumulation of large woody debris; (5) place dredged material; and, (6) remove armor from shorelines. Such ecological restoration requires that detrimental changes be reversed to a measurable degree. However, existing data collection and analytical methods are insufficient to evaluate the cumulative benefits to the ecosystem or salmon populations.
Objectives:
1. Support the cumulative effects assessment at a pilot and estuary wide scales through field work to document the selected higher-order metrics, develop time-series, and expand the spatial and temporal diversity of sites for cumulative effects analysis:

At Kandoll, Crims Island, and Vera restoration and reference sites sample all the core metrics (Roegner et al., 2008) plus material flux.
At Julia Butler Hanson, sample hydrology, vegetation, and flux and use HEC-RAS to model wetted-area for the Cumulative Effects Study.
At selected natural breach sites, sample hydrology, morphology, vegetation, and fish abundance.
2. Test estuary wide the cumulative effects analysis methodology developed in previous years, including GIS assessments, discrete hydrologic modeling, and meta-analyses.
3. Support the Corps to implement an adaptive management framework developed in FY08 to support decisions by the Corps and others regarding LCRE habitat restoration activities.

Title: Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary
Sponsor: PNNL/UW
Summary: Although existing projects within the Anadromous Fish Evaluation Program and the Columbia Basin Fish and Wildlife Program address many of the FCRPS BiOp RPA actions, there are gaps in coverage of RPA Actions 58, 59, and 60: life history diversity index, habitat connectivity index, and estuary restoration-associated survival benefits. One of the goals of habitat restoration in the lower Columbia River and estuary (LCRE) is to increase salmonid life history diversity. Therefore, as called for in Action 58, a quantitative method is needed to index and periodically monitor life history diversity in the LCRE. Another goal of the LCRE habitat restoration effort is to increase habitat connectivity thereby improving the opportunity for juvenile salmonids to access shallow-water, off-channel habitats where they can forage and find refuge from predators during their migration to the ocean. A method to quantify and periodically monitor habitat connectivity, however, has not been developed and applied for the LCRE, as required by Action 59.

The 2008 Biological Opinion included an assessment of the survival benefits of habitat restoration actions in the LCRE proposed in the Biological Assessment. The assessment was necessarily based on professional judgment using the best available knowledge because data on incremental benefits to juvenile salmonid survival associated with specific restoration projects do not exist for the LCRE. This research need regarding survival benefits pertains to Action 60, calling for evaluation of habitat restoration actions. It is not certain that increased survival as an outcome of restoration can be measured and/or indexed in terms of life history diversity or habitat connectivity, but an evaluation of the potential is necessary given the requirements of the BiOp.
1. Develop and test with existing data quantitative methods to apply in the lower Columbia River to index:
    a. Life history diversity for salmonids at representative locations;
    b. Habitat connectivity by reach estuary wide
2. Assess feasibility and, if feasible, develop a technical approach to estimate the survival benefits associated with specific habitat restoration actions in the lower Columbia River and estuary.

Title: Pile Structure Evaluation Coal Ck
Sponsor: PNNL/USGS
Summary: This is the pilot study for monitoring action effectiveness of a pile removal.

Includes water quality and habitat monitoring, occurring once before project implementation Effectiveness: Water quality and habitat monitoring occurring during implementation and/or post-implementation.

Title: Julia Butler Hanson Tide Gate Replacement
Sponsor: USFWS/PNNL
Summary: Baseline monitoring of tide gate replacement and installation project sites at the Julia Butler Hansen (JBH) National Wildlife Refuge was carried out in 2007. The refuge is located near Skamokowa, Washington at about river kilometer (rkm) 55. The U.S. Corps of Engineers (USACE) is constructing multiple tide gates on this U.S. Fish and Wildlife Service site in phases, beginning in 2008. Therefore, 2007 baseline monitoring was conducted on Ellison Slough and Duck Lake Slough, both slated for 2008 construction, as well as an unnamed channel with a previously replaced tide gate. Baseline monitoring of 2009 construction sites is planned for 2008. Monitored indicators included landscape features and vegetation. Water properties flux monitoring was initiated in 2007 as well on a four-season sampling plan.

Title: Crims Island Restoration Monitoring
Sponsor: USGS
Summary: In 2005, the Corps' Portland District implemented a restoration project at Crims Island located at river kilometer 88 in the lower Columbia River. The restoration action included breaching a dike in two locations, removing material to the correct elevation for tidal wetland development, and the excavation of tidal channels. Monitoring of this project provides an opportunity to assess habitat improvement at the site and, in conjunction with other restoration project evaluation, to assess the cumulative ecosystem response to habitat restoration. The monitoring objectives were to:
1. Assess fish community composition and fish passage at the restored areas.
2. Collect post-restoration monitoring data on vegetation, elevation, and channel development during 2006 and 2007.
3. Collect data on the flux of ecosystem components in and out of the restored site.

Title: Tenasillahe Island Restoration Monitoring
Implementer: USFWS
The Corps will improve tidegate outlets at existing locations in the flood control levee surrounding Tenasillahe Island and construct inlet structures and channels at two locations to improve fisheries access and egress and improve water circulation in interior channels. Monitoring actions for the interim feature will cover 3 years in the estimated 10-year life of this feature and then be discontinued with implementation of the long-term restoration feature for Tenasillahe Island.

Title: Juvenile Salmonid Stranding
Sponsor: PNNL/UW
The overall goal of study is to address the impact of the deepening project on juvenile salmon stranding, specifically, to assess the consequence of dredging to deepen the navigational channel on the risk of fish stranding by commercial vessels.
The two objectives of the study are to:

Assess the effect of channel deepening on the risk of juvenile fish stranding with a before and after comparison, and
Determine the magnitude of wake and the resulting wave run-up generated by passing vessels before and after channel deepening and relate the wake to ship characteristics and shoreline physical factors with factors analysis.

Other related work:

Title: USGS - Water quality monitoring
Summary: Objective: To provide an ongoing characterization of the concentrations and mass flux of sediment and chemicals - 3 sites in LCRE (Warrendale, Beaver, and Willamette River at Portland).Metric: Water-soluble pesticides, suspended and dissolved trace elements, major ions, nutrients, carbon, and suspended sediment
Metrics: Ammonia, nitrate & nitrite, total phosphorus, specific conductance, total nitrogen, suspended solids, fecal coliform bacteria, oxygen, temperature, flow, pH, turbidity, metals, soluble reactive phosphorus

Title: Ramsey Lake Project Monitoring
Sponsor: City of Portland, Bureau of Environmental Services
Project Funder: NOAA Coastal Restoration Program
Summary: The primary reason for funding this project is NOT the FCRPS BiOp. The project is included anyway because it provides data that can be used to inform estuary/ocean RME. Data may be useful to others for meta-analysis of action effectiveness research data.

Proposed new work

Draft Columbia River Accord (Washington - under review)

Proposed projects:

1a WDFW Umbrella Project - WDFW Component
1b Lower Columbia Fish Recovery Board (LCFRB) Component
2 Abernathy Tidal Restoration
3 Germany Tidal Restoration
4 Lower Kalama Tidal Restoration
5 Acquisition of Chaney Parcel at Wood's Landing and Restoration of Chum Salmon Spawning Tributary
6 Ft. Columbia Tidal Reconnection
7 Fish- Hump Island Restoration
8 Paradise Point Wetland Enhancement
9 Austin Point LWD Complexing
10 Elochoman Tidal Restoration
11 Willow Grove Tidal Restoration
12 Shillapoo Wildlife Area/Post Office Lake Setback Levees
13 Duncan Creek Fish Passage Restoration
14 Pile Dike Removal
15 Burke Island Hydrology Improvements
16 Lower Washougal Delta Habitat Complexing
17 Lower Kalama Delta Habitat Complexing
18 Chinook River Estuary Restoration
19 Lower Cowlitz Tidal Restoration
20 Lewis River Acquisition
21 Port of Kalama Off-channel Wetland Enhancement
22 Cottonwood/Howard Island Tidal Channel Connections
23 Barlowe Point Beach Nourishment